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THE

ADVANTAGES AND ACCIDENTS

OF

ARTIFICIAL ANÆSTHESIA

A MANUAL OF ANÆSTHETIC AGENTS,

AND THEIR

EMPLOYMENT IN THE TREATMENT OF DISEASE.

BY

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WITH TWENTY-SEVEN ILLUSTRATIONS.

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PREFACE TO THE SECOND EDITION.

The rapid sale of a large edition of this work in the short period of one year, shows the appreciation with which it has been received by the medical and dental press and professions. Its success has induced the author to revise the subject matter and rewrite several of the articles. To make the volume more worthy of the favor of the profession, a number of new and original experiments have been made; especially with hydrobromic ether. The boiling points and relative time of evaporation of the several agents employed in mixed anæsthetics, and the best proportion in which ether, alcohol, and chloroform should be united, have been determined; also a continuation of the experiments on the action of anæsthetics on the blood, the use of the spectroscope in relation to anæsthetics, more especially nitrous oxide.

In this second edition there will be found many more practical suggestions as to the employment of anæsthetics that are safe, and the rules for their adoption or reasons for the rejection of some of them in different cases, grouped, and made convenient, so that the student can memorize them, and be fully prepared for any emergency. As has been well observed in a review of this work by the distinguished editor of the *Dental Cosmos*, "When trouble comes to a patient from any cause during the anæsthetic state, it is not a good time to hunt up information."

The new table of deaths from chloroform which has been added, and in the preparation of which much time and labor has been expended, will be found of special interest and vital importance in regard to the sex, age, character of operation, time at whieh the patient died, quantity of chloroform used, and form of apparatus employed, general condition of patient, prominent symptoms of chloroform-poisoning, causes of death and post-mortem appearances. A new ether inhaler has been described and illustrated, which has been, and is now, employed in the clinical service of Jefferson College Hospital.

A bibliography published in the first edition has been omitted, but additional old or new works which were not then introduced, or cannot be found mentioned in the body of this work, have been printed for reference.

A historical sketch of the discovery of anæsthesia at the end of the previous edition has also been omitted, as more space has been devoted to the subject in our introduction, but full references to all the authorities on the subject have been given.

There has been introduced a notice of the metric system in accordance with the recommendations of the "American Medieal Association" at its last meeting, at Atlanta, in May, 1879; also a table of the Centigrade, and Fahrenheit thermometric scales. More spaee has likewise been assigned to the physiological and therapeutic action of anæsthetics in disease. In most of the instances where a remedy has been recommended, the authority has been quoted, or we have tested its therapeutic value in an extensive private practice, or in the daily clinics of two large public institutions.

It was found impossible to acknowledge, in every instance, the source from which all contained facts have been

obtained, but in the majority of instances we have endeavored to give credit to every original worker in the field of progress.

The author desires to acknowledge many courtesies at the hands of several eminent members of the profession, but he is especially indebted to his son, Dr. Charles S. Turnbull and to Dr. Charles E. Sajous, resident physician of Howard Hospital.

1502 WALNUT STREET,
June, 1879.

PREFACE TO THE FIRST EDITION.

THIS little work was originally written by the Author as a report for a medical society, and was subsequently extended to its present form to supply a want that evidently exists at the present day, for a convenient hand-book on the administration of the various anæsthetics, that the practitioner of medicine or dentistry can consult to enable him to decide which one he can best employ. Many valuable books have, unquestionably, been written on the subject of anæsthetics, but as far as the writer's observation extends, none of a practical character have appeared within the last few years. Much useful matter in relation to sulphuric ether, nitrous oxide, and chloroform, employed as anæsthetics, has accumulated within this period, but this valuable information is contained in various monographs, journals, etc., where, associated with what is extraneous, it is unprofitable to the busy practitioner.

The object of this work may be stated to be:—

First. To give in as concise a manner as possible a description of the most available agents that may be successfully and safely employed as anæsthetics.

Second. To present the chief chemical tests of the purity of each substance considered, with its composition, physical characters, and medical properties.

Third. To exhibit the best methods of administering the various anæsthetics, to give careful directions, and to state

the precautions to be taken to avoid risk to the life of the patient.

Fourth. To note the personal experience of the author, his assistants and friends, with the various forms of anæsthetics and inhalers in use, with a selection of the most approved of them, not withholding, however, the objections and experiments of other reliable investigators.

Fifth. To compare the relative mortality from all the anæsthetics now employed, endeavoring to assist the reader in forming a fair and candid opinion on this most important subject, which is now, and has for so long a period, occupied the attention of the public as well as of the medical profession.

To conclude are added practical hints on Local Anæsthesia, the use of the various anæsthetics in the practice of medicine; the Medico-Legal Nature and Importance of Anæsthetics, with a brief History of the discovery of Artificial Anæsthesia.

1502 WALNUT STREET,
March, 1878.

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INTRODUCTION.

ANÆSTHETICS OF THE ANCIENTS.

THE ancient Greeks, it is stated, possessed a plant called mandrake. It belonged to the same family of plants as the belladonna, or deadly nightshade. From the root of this plant was extracted, by means of wine, a narcotic which was employed by them as an anæsthetic. Lucius Apuleius, who lived about 160 A. D., and of whose works eleven editions were republished in the fourteenth and fifteenth centuries, says "that if a man has to have a limb mutilated, sawn, or burnt, he may take half an ounce of mandragora wine, and whilst he sleeps the member may be cut off without pain or sense." To prove that this was true, Dr. B.W. Richardson, of London, after a lapse of five centuries, obtained a fine specimen of mandragora root, and made mandragora wine and tested it, and found it was a narcotic having precisely the properties that were anciently ascribed to it. He found that in animals it would produce even the sleep of Juliet, not for thirty or forty hours, a term that must be accepted as a poetical license, but easily for the four hours named by Dioscorides; and, on awakening, there was an excitement which tallied with the same phenomenon that was observed by the older physicians. Another fact was noticed by the ancients, that many volatile substances acted more promptly by inhalation than by the stomach, and this form of medication was employed in Greece, Rome, and Arabia. By their published works, the knowledge of these facts was extended to other parts of the world.

In China, in ancient times, the word *ma-yo* meant not only Indian hemp, but anæsthetic medicine; other substances besides hemp entered into these benumbing recipes,

such as the datura, a solanaceous plant, probably identical with the atropia mandragora; also aconite, hyoscyamus, etc. Some of these drugs form constituents of the formula said to be employed by kidnappers of children, and robbers, and are therefore naturally forbidden in China, at the present, to be sold or employed.

The Indian hemp, under the name *bhang*, was extensively used by the Mohammedans and others in Central Asia. The most wonderful properties are ascribed to it. "Taken in excess, the spirits and demons may be seen; it confers prophetic powers; it is sometimes taken by persons wishing to indulge in spiritualism, and it is used as an antidote to forgetfulness." (Dudgeon.)

Theodoric, about the year 1298, gives elaborate directions how to prepare a "spongia somnifera" by boiling it dry in numerous strong narcotics, and afterwards moistening it for inhalation before operations.

Opium was also employed in later years (prior to surgical operations), and was found one of the best of narcotics for the relief of pain and for producing insensibility, but was not free from danger.

On September 3d, 1828, M. Girardin read, to the Academy of Medicine of Paris, a letter addressed to His Majesty Charles X, describing surgical anæsthesia by means of "inhaled gases."

Richerand suggested drunkenness in reducing dislocations; and patients, while dead drunk, have been operated upon painlessly. Larry, after the battle of Eylau, found in the wounded, who required amputations, a remarkable insensibility, owing to the intense cold, this being the first use of cold as an anæsthetic.

A strong impulse was given to the study and application of the "different kinds of airs and gases" by the discovery of oxygen by Priestley and Scheele, in the middle of the last century, and numerous experiments were made by physicians with it. Another still more practical result was obtained by Sir Humphrey Davy, and published in 1800. "That nitrous oxide appears capable of destroying physical pain, and may be used with advantage during surgical operations." This valuable and practical suggestion remained without fruit for a long time, and the surgeons, physicians,

and accoucheurs still employed alcohol in some form, or opium and its salts, to deaden as far as possible the sensibility to pain during their various operations. It was not until 1844 that an effort was made in the United States by Dr. Wells, of Hartford, who experimented with it in fifteen cases with varying success; but he employed too small a quantity of the gas. In April, 1848, Dr. Bigelow, of Boston, demonstated its value in surgery by performing an excision of the breast, using sixty gallons of the gas. But the crowning result was obtained in 1846 by Dr. Morton, in the Massachusetts General Hospital, when it was demonstrated successfully that the inhalation of "ether" was so capable of deadening the sensibility of the nervous system, that any operation, no matter how painful, could be performed and the patient not suffer from its effects. It was also proven that ether was safe and like the wine that Juliet drinks, the action of which the Friar Lawrence so well describes:—

> "Through all thy veins shall run
> A cold and drowsy humour, which shall seize
> Each vital spirit; for no pulse shall keep
> His natural progress, but surcease to beat:
> No warmth, no breath, shall testify thou liv'st;
> The roses in thy lips and cheeks shall fade
> To paly ashes; thy eyes' windows fall,
> Like death when he shuts up the day of life;
> Each part, deprived of supple government,
> Shall stiff, and stark, and cold appear like death:
> And in this borrow'd likeness of shrunk death
> Thou shalt remain full two and forty hours,
> And then awake as from a pleasant sleep."

This most valuable agent required but to be inhaled for a few minutes, when the patient, being in a pleasant frame of mind, would thus remain asleep; and after a more or less prolonged operation, "would awake and inquire if the diseased limb were still there, and could be told that the offending member was gone, without his knowledge."

No one can form, even at the present day, a just estimate of the true value of the various anæsthetics, or express in words their wonderful and extended application to the relief of human suffering.

To the general surgeon it gives the opportunity of operating in grave cases of disease and injury, without which, the death of the patient would be inevitable. It also affords, by

the immediate relief from pain, the power to manipulate the broken or injured parts with facility, and thus obtain a correct diagnosis in the most obscure diseases and painful accidents.

To the obstetrician and gynæcologist it is useful in assuaging the terrific pain of labor, and makes the dreaded instruments a blessing in disguise. In the diagnoses and treatment of abdominal diseases, it gives precision and almost marvellous results, and in the removal of large masses or tumors great freedom from the dreadful effects of shock to the nervous system. For the ophthalmic surgeon the anæsthetic reduces the sensibility of the eye so that it can be touched with impunity, and severe and dangerous operations can be performed upon this delicate and sensitive organ without pain and with much less risk.

Again, in the removal of foreign bodies from the eye or ear, particularly in children, by the use of the anæsthetic all spasm is relieved, and the act is accomplished without injury. The profound sleep gives a most favorable opportunity to the aural surgeon to perforate the membrana tympani, cut the minute tendon of the tensor tympani muscle, or perforate the mastoid cells.

There are some thirty substances which are of so volatile a character, that they can be employed in producing anæsthesia. The following is a

LIST OF THE PRINCIPAL AGENTS THAT WILL PRODUCE ANÆSTHETIC SLEEP OR LOCAL ANÆSTHESIA.

Nitrous oxide gas.
Carbonic oxide gas.†
Carbonic acid gas.*
Bisulphide of carbon.*
Light carburetted hydrogen.*
(Hydride of methyl, or marsh gas.)
Methylic alcohol.
Methylic ether gas.
Chloride of methyl gas.
Bichloride of methylene.
Terchloride of formyl, or chloroform.
Tetrachloride of carbon.*
Bromoform.
Heavy carburetted hydrogen gas.*
(Olefiant gas or ethylene.)

* Those agents having the stars affixed are not safe for inhalation, and are more fitted for producing local anæsthesia.

† Carbonic oxide has been used as a local anæsthetic to cancerous or raw surfaces; but, when inhaled, it is a powerful narcotic poison. Owing to its superior affinity, it displaces the oxygen in the red blood-corpuscles, and unfits them for the functions of respiration.

Ethylic, or absolute ether. (Sulphuric ether.)	Bromide of ethyl, or hydrobromic ether.
Chloride of ethyl.	Hydride of amyl.*
Bichloride of ethylene. (Dutch liquid.)	Amylene.*
Bromide of ethylene.	Benzole.*
	Turpentine spirit.*
	Gasoline.*

And all of the liquid chlorides, bromides, and iodides of alcoholic radicals.

Those anæsthetics which are employed at the present day, in the practice of medicine, may be reduced in number to four; namely, alcohols, ethers, chloroform, and nitrous oxide. These can be employed alone, or mixed in various proportions. They can be reduced to a still smaller number, viz., nitrous oxide gas, and alcohol of various grades of power, as each of the eleven alcohols will, by the chemical action of an acid, produce its ether or chloroform.

* Those agents having the stars affixed are not safe for inhalation, and are more fitted for producing local anæsthesia.

CHAPTER I.

General Anæsthetics—Alcohol and Ethyl Alcohol. Methylic Alcohol for inhalation; mode of action; its resemblance to Chloroform.

It has long been recognized as a fact that, when persons are under the controlling influence of alcohol, either in the form of wine, gin, whiskey, or brandy, they may be cut, bruised, or even have their bones broken, without expressing, or experiencing much, if any pain. Alcohol was very early employed by surgeons to produce immunity from the pain of the knife, long before any true anæsthetic was discovered. Dr. John Lynk* states that he has long employed alcohol as an anæsthetic, and that he has gradually learned to appreciate it more and more, using it now almost entirely in his surgical operations. He has not as yet tried it in a capital operation, but has employed it, in the proportion of about one pint for a strong adult, in tablespoonful doses every twenty minutes in an amputation of the finger, extraction of teeth, in a case of severance of the posterior tibial nerve; with the use of chloroform, also, ligation of radial and ulnar artery, in which he only used two drachms of chloroform and one pint of whiskey. This latter operation he thinks served to demonstrate the value of the whiskey as an anæsthetic, leaving the other functions, especially the heart, in a more normal condition than by the chloroform alone, which he states, was proven by the strong pulsations of the heart after the chloroform had been withdrawn.

We have tried the inhalation of whiskey, but owing to its mixture with water and fusel oil and other carbonaceous products, it will not produce anæsthesia rapidly. If rye whiskey be pure and strong, and free from water and other products, it will produce anæsthesia if applied with the atomizer or by inhalation.

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* Cincinnati Lancet and Observer, May, 1876.

ETHYL ALCOHOL (C_2H_5OH).

This compound is manufactured on a large scale, and is the most important body of the whole group, being the starting point for the preparation of all the other ethyl compounds. Ethyl alcohol, or spirits of wine, is obtained by the vineous fermentation of the sugar in the various grains, a decomposition taking place in the dilute solution of sugar in the presence of yeast, by which the greatest portion of the sugar is resolved into carbon-dioxide and ethyl alcohol.

$$C_6H_{12}O_6=2CO_2+2C_2H_6O.$$

In England the "proof spirit" of the excise contains 50.8 per cent. by weight of alcohol, and has, at 15.5° (60° F.), the specific gravity of 0.920. Owing to the high duty on pure spirit, the government allows the sale of a mixture of ninety parts of strong spirit and ten parts of crude wood spirit, called "methylated spirit," for manufacturing and scientific purposes; this being, therefore, a mixed carbonaceous compound not fitted to produce a pure ether. Ethyl unites with dry chlorine acid gas, and forms ethyl chloride, $C_2H_5Cl.$; also with bromine, sodium, and iodine, forming ethers.

In the United States, alcohol is usually obtained by the distillation of rye, barley, corn, or wheat whiskey. Thus obtained, it is a clear liquid, containing more or less water, which by redistillation, in conjunction with lime, becomes what is known as absolute alcohol. It is difficult to inhale pure alcohol (ethylic), as it causes great irritation of the throat and spasm of the glottis; but if diluted with water and thus inhaled, anæsthesia will be produced as before stated.

There are two other alcohols which are found in commerce, one called methylic, and the second amylic alcohol. The methylic alcohol is obtained by the dry distillation of *wood*, and the amylic by the distillation of *potatoes*. They are both used for adulteration and for commercial purposes.

METHYLIC ALCOHOL.

Pyroxide spirit, or wood spirit, as this has been differently called, has been known for about sixty-two years, and when analyzed by Messrs. Dumas and Peligot, it was found to

contain 37.5 per cent. of carbon, 12.5 per cent. of hydrogen, and 50 per cent. of oxygen. When pure, it remains clear in the atmosphere. It has an aromatic smell and taste, with slight acidity, and boils at 140° F. According to the experiments of Dr. B. W. Richardson, of London, this alcohol, owing to its volatile nature, may be exhibited freely by inhalation, in the same manner that chloroform is administered. It then enters the blood by being carried with the air that is inspired into the pulmonary tract, and thus into the air vesicles; here it is absorbed into the circulation by the minute blood-vessels which make their way from the heart through the lungs, and which ramify upon the vesicles. By administering the vapor of methylic alcohol in this way, its effects are rapidly developed, for it condenses quickly in the blood, is carried rapidly into the left side of the heart, and thence is distributed by the arteries over the whole body, as quickly as can be condensed and absorbed.

This alcohol is recommended by Dr. Richardson, and he has obtained better results from its use than from the heavier or ethylic spirit. It is much more rapid in its action, and much less prolonged in its effects than common alcohol; and, what is of more importance, it demands the least possible ultimate expenditure of animal force for its elimination from the body. According to the same authority the lighter the alcohol, therefore, *cæteris paribus*, the less injurious its action. When inhaled, its effects are developed in four distinct stages.

First stage, there is excitement, flushing of the body, and dilatation of the pupils; after a time there follows languor, and the muscular movements become irregular.

Second stage, muscular prostration, and labored breathing, attended by deep sighing movements and rolling over of the body.

Third stage, complete insensibility to pain, with unconsciousness to all external objects, with inability to exert any voluntary muscular power. The breathing now becomes embarrassed and blowing, with bronchial râles, due to the passage of air through fluid that has accumulated in the finer bronchial passages. The heart and lungs, however, even in this stage, retain their functions, and therefore recovery will take place if the conditions for it be favorable.

Also, if the body be touched or irritated in parts, there will be a response of motion, not from any knowledge or consciousness, but from reflex action. During all these stages there is no violent convulsive action, but, step by step, a reduction of temperature, so at last the loss of heat will become dangerous, for the cool body cannot throw off the water freely, and therefore fluid collects in the lungs and there is a risk of suffocation, as from drowning. If the administration of the methylic spirit be continued when the third degree has been reached, there is a last stage, which is that of death. The two remaining nervous centres which feed the heart and respiration cease simultaneously to act, and all motion is over. If, however, after the third stage of insensibility the administration of methylic spirit be stopped, recovery from the insensibility and prostration will invariably take place *on one condition*, that the body be kept warm for seven hours.*

There is but little doubt that this sudden reduction of temperature is one cause of death after the administration of ether and chloroform. The patient is apparently all right, and is transferred to the ward from the warm operating room; no special means are employed to keep up the temperature, and gradually the patient sinks into an unconscious state, from the fluid which collects, and dies from congestion of the lungs, the result of neglect.

A memoir recently presented to the French Academy states that injurious effects are often produced by the continued inhalation of vapor of methyl alcohol; for example, on workmen who are using it.

ALCOHOL AS A LOCAL ANÆSTHETIC.

In the use of snow or ice there is more or less pain in the part until it is frozen. By substituting cold alcohol the parts can be immersed in it for a long time, so as to deprive them of ordinary sensibility; and, although the faintest touch can be perceived, cutting or pricking them can be well borne.

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* On Alcohol. A course of six Canton Lectures, delivered before the Society of Arts (London, 1875, by Benj. W. Richardson, M. A., M. D., F. R. S.).

Alexis Horvath, of Kieff,* states:—

"Knowing the painful sensation experienced by immersion of the hand in water at a temperature of 0. C., I was much astonished to not experience the same sensation with the hand in alcohol, the temperature of which had been reduced to —5° C.

"The discovery of this curious fact, which was made by me as early as 1869, led me to undertake some experiments, of which I give briefly the results.

"When the finger is held in sulphuric ether or mercury at the temperature of —3° C., the same painful sensation is experienced as when it is immersed in water at zero C.

"On the other hand, when we plunge the finger, even for a longer time, into alcohol or glycerine at the temperature of —5° C., we feel no pain.

"A prick in the finger, while it is immersed in cold alcohol, produces no pain, and only a sensation of contact, thus proving that there is a distinction between the sense of tact and that of pain, and affording us the means of proving it. It is seen thus that pain is not the sense of tact intensified, but rather an altogether different sensation.

"These experiments demonstrate that it is not merely the cold that plays a part in the production of anæsthesia, but also the liquid employed; in this regard the various liquids act differently. Inasmuch as death following severe burns is partly attributed to the intense pain which accompanies them, I was led to utilize alcohol in their treatment. I have had numerous occasions to recognize its efficaciousness—among others, in a child burnt in the hand (to the second degree); the pains disappeared at once on plunging the hand into alcohol, to reappear again on its withdrawal. Moreover, I observed that burns submitted to this treatment were cured in much less time than those treated otherwise.

"Anæsthesia by cold (according to the methods of Richardson, etc.), though known and appreciated for a long time, is relatively little employed, solely on account of the inconveniences of the procedure. These inconveniences, joined to the above observations, have led me to attempt

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* Gazette des Hôpitaux, No. 105, September 10th, 1878.

anæsthesia by cold in grand operations, and in extensive burns located elsewhere than in the extremities."

I have repeated these experiments, and can corroborate the main facts, *i. e.*, regarding the loss of sensibility. When a finger, upon which there was a felon, was immersed in alcohol of 20° F., it could be manipulated with impunity; whereas, before the immersion, the member was so sensitive that the slightest touch caused excruciating pain.

"Freezing the skin with ether spray sometimes temporarily removes sciatica or neuralgia, but the relief generally is but temporary. The skin, or mucous membrane, when sufficiently frozen to permit of a painless operation, becomes pale, shrunken, tallowy-looking, and feels as if oppressed with a great weight. Whilst recovering the natural condition, the frozen tissues tingle and smart, sometimes so intensely as to exceed the pain of the operation."—RINGER.

CHAPTER II.

Ether—The ordinary methods of administering: towel, cone, sponge, or bag. Test when patient is fully under its influence. Physiological Action of Ether. Cautions in regard to Solid Food before Etherization. Cases in which Ether should not be employed as an Anæsthetic. The three stages of Etherization. Sulphuric Ether—Always gives Warning. Use of Air, Artery Forceps, Artificial Respiration in Fainting, etc. Statistics in Reference to Death. Experiments by the Sphygmograph. Primary and Secondary Effects. Table of Deaths from Ether. Abstract of Report of Boston Committee. Inflammability. Conclusions of Author.

ETHYL OXIDE, ETHYL ETHER, $\left.\begin{matrix}C_2H_5\\C_2H_5\end{matrix}\right\}O.$

THIS body, commonly called "ether," is manufactured on a large scale by heating a mixture of strong alcohol and concentrated sulphuric acid to 140°. The reaction takes place in two stages: in the first, ethyl sulphuric acid and water are formed:—

$$\left.\begin{matrix}C_2H_5\\H\end{matrix}\right\}O+\left.\begin{matrix}H\\H\end{matrix}\right\}SO_4=\left.\begin{matrix}C_2H_5\\H\end{matrix}\right\}SO_4+\left.\begin{matrix}H\\H\end{matrix}\right\}O.$$

The ethyl sulphuric acid acts at 140° upon another molecule of alcohol; hydrogen and ethyl change places, and ether and sulphuric acid are formed:—

$$\left.\begin{matrix}C_2H_5\\H\end{matrix}\right\}SO_4+\left.\begin{matrix}C_2H_5\\H\end{matrix}\right\}O=\left.\begin{matrix}H\\H\end{matrix}\right\}SO_4+\left.\begin{matrix}C_2H_5\\C_2H_5\end{matrix}\right\}O.$$

The ether and the water produced are distilled off, whilst the sulphuric acid remains behind, ready to convert another quantity of alcohol into ether.

The ordinary ether sold has a specific gravity of 0.750. When shaken with an equal quantity of water it loses $\frac{1}{5}$ of its volume. *Ether fortior* should have a specific gravity of 0.728, and will not, when shaken with an equal bulk of water, lose more than $\frac{1}{8}$ of its volume. If pure, ether will not redden litmus paper.

The specific gravity of chemically pure ether is 0.713—0.725, and its boiling point 95° F. A test tube filled with it

and held in the warm hand should boil on the addition of fragments of broken glass. In hot countries, like India and our own, or in the close wards of a hospital, if preserved in imperfectly stoppered bottles, ether will absorb oxygen and forms acetic acid, becomes impure, and is therefore unsuitable for inhalation.

Ether does not mix with water, but is slightly soluble in it; it mixes readily with alcohol.

The ether which is most generally employed in Philadelphia, and, indeed, throughout the United States, is that manufactured by the reliable firm of Powers & Weightman, and it is uniformly of most excellent quality. The ether of Dr. Squibb, of Brooklyn, N.Y., is resorted to; it is of higher price and is freer from water, and, we think, is more apt to produce irritation if used too freely; this can be obviated by moistening, with warm water, the sponge cone, or inhaling apparatus. If in doubt about the purity of your ether, agitate it with lime-water and then decant it before using.

Ether by inhalation was resorted to for years to induce a state of exhilaration, when a small quantity was mixed with a very large quantity of air. The great invention of Dr. Morton was to cause complete insensibility to pain without danger, causing true anæsthesia, this being graduated by increasing the quantity of ether and diminishing the supply of air until the insensibility be completely obtained, without however passing the limits in which stupor could be arrested short of danger.

The ordinary method in use of administration of the first discovered anæsthetic, namely, washed sulphuric ether, is as follows:—

An inhaler is made by folding a towel into a large cone or bag, and then placing a coarse sponge in its apex. Ether is then poured upon it with a free hand—half an ounce or more at a time—and repeated as necessary by removing the cone from the patient's mouth to renew the supply of ether. The lower part of the face, mouth, and nose is covered with the cone so as to exclude most of the air, and allow the patient to fill his lungs with more or less diluted ether vapor, depending on the care with which the cone is applied. There will be, at the beginning of the inhalation, attempts

to struggle, on account of the irritating nature of the ether, which are to be gently, but firmly restrained, using as little force as possible, and only one or two inspirations of pure air allowed; subsequently complete quiescence usually follows, and the patient passes into a profound state of insensibility. If, however, the face become livid or very pale, the cone is lifted entirely away for a time until this condition disappears. In delicate persons, it is well to notice any unusual slowness or intermittence of the pulse. One of the best tests of the patient being fully under the influence of the ether, is when the conjunctival surface of the eye can be touched with impunity, and the arm can be raised and will fall as if paralyzed. Dr. Snow states that he found the eye sensible to light in all stages of etherization.

PHYSIOLOGICAL ACTION OF ETHER.

The functions of the cerebrum or brain are affected before those of other portions of the nervous system. After a more prolonged inhalation the anterior or motor centres soon fail to respond to mechanical irritation, yet the functions of the medulla-oblongata are performed.

If the inhalation of ether is still further carried on, according to Flourens, the sensory, and finally the motor, functions of the medulla-oblongata are involved, and death occurs from a paralysis of the respiratory centres. Longet states that he found the sensory functions abolished very early, but he has never failed in any stage of the narcosis from ether to get a response from the anterior part of the cord by employing powerful galvanic currents.

Ether should not be inhaled immediately after a full meal, indeed it is better to take only a biscuit or cracker and a glass of wine or a teaspoonful of brandy and water, or a scruple of bromide of potassium in water, half an hour before, always avoiding for several hours previously the risk and annoyance of a full stomach. Nothing like hard boiled eggs, ham, or beef should ever be allowed a feeble patient before inhalation for twenty-four hours. If nourishment is necessary, let it be of a liquid character; as solid food, not digested, has been the cause of death in more than one person.

Perfect quiet should be enjoined on all around the patient,

as noises, or even loud talking, interfere with the perfect and rapid action of the anæsthetic. Nothing like a tight band or garment should prevent the free action of the throat, chest, or interfere with the muscles of respiration. False teeth should always be laid aside until after the inhalation is over. There are a few

CASES IN WHICH ETHER SHOULD NOT BE EMPLOYED AS AN ANÆSTHETIC.

These we shall endeavor to enumerate. The first class is in very aged persons with emphysema, hypertrophy of the heart, fatty heart, or great valvular lesion. The second class are those who are known to faint from very slight causes. The third class are habitual drunkards, or persons who drink in small quantities frequently each day. The fourth class is from limited action of the lungs by adhesions from old pleurisy, or pneumonia, or irritation of the mucous membrane with excessive secretion.

In anæsthesia by ether, the real danger to be avoided is over-inebriation. It may be divided into three stages.

First stage, of exhilaration; second stage, that of stupor with snoring, or complete insensibility, which, with care, can be gradually increased or diminished with safety; third, dangerous state, that of *coma* with stertor, or the patient becomes livid with true asphyxia, or may alternate between lividity, with a falling pulse, with apparently alarming indications.

There are a certain class of patients that pass into an almost profound state of unconsciousness without these distinct stages, while others require two or three assistants to hold them while inhaling, and have a wild excited stage, then pass, after a longer or shorter time, into the stage of stupor; these latter are termed by those who are familiar with the administration of anæsthetics "bad etherizers," and here comes the importance of experience. Indeed, no one should be trusted with the inhalation unless he has passed through a course of instruction; for, unless great discretion is shown in giving or withdrawing the agent, the result may be fatal, while, with proper care, even in these bad cases, you may ultimately reach a stage of stupefaction, and all go well. The following case illustrates another class:

October 4th, 1877, Jefferson College Hospital. In a case of mastoid disease, in which I perforated the bone and opened the cells, my friend, Dr. Allis, administered the ether, the patient made but little effort at respiration; and, after consuming from six to eight ounces of ether for a full half hour without producing the true anaesthetic result, we had to resort to the use of chloroform, pure and alone. This is not the first case in which, in the hands of even the most careful administrators, the ether has not produced the desired result, and we are under the necessity of resorting to the use of the more dangerous agent; but this must not be done until a full and free trial of the milder and safer agent, always in careful hands, and only in the most important and very painful operations.

SULPHURIC ETHER AS AN ANÆSTHETIC

Is not altogether free from danger, but it always gives warning before it causes the death of the patient. The countenance should be watched, and the difficulty in breathing promptly attended to the moment the face assumes a purple, dusky, or extremely pale hue. The first thing to be done is to remove the inhaling apparatus, and admit fresh air; if this is not sufficient, draw forward the tongue by means of a pair of artery forceps, or a napkin or handkerchief wrapped around it; also, draw forward and support the jaw. If these means should fail to reëstablish a healthy action of the lungs and cause due oxygenation of the blood, resort at once to artificial respiration, by means of Marshall Hall's method, or mouth of the physician to that of the patient, or by the use of a small pair of hand bellows, or air-bag and nozzle having its valve on the side or base.

A careful examination was conducted by the Royal Medical Chirurgical Society of London into the comparative merits of ether and chloroform, by means of the hemadynamometer in testing the effects on the heart's action and the influence of these agents upon it. The report states: "The essential difference between the action of chloroform and ether is to be found in the effect produced upon the heart. The first operation of both agents is to stimulate the heart and augment the force of its contractions; but, after this, chloroform *depresses* the heart's action, whereas ether ap-

pears to exert but little influence upon the muscular movements of that organ."

The general accuracy of these results, although tested by so comparatively coarse an instrument, is borne out by careful experiments made with the sphygmograph by the late Dr. Morgan,* of Dublin, who, with this delicate instrument, made numerous observations which are here given, and concludes as follows: "I have taken all but one of these examples (eight cases) as the most unpropitious, occurring in patients of diminished health and vitality, yet it is evident that the most perfect anaesthesia could be invoked under the influence of ether, with an absolute stimulating effect on the circulation; and that the condition of insensibility could be maintained for a considerable time, yet there was no material alteration of the 'pulse writing,' and the most perfect sense of security was established. *It is, therefore, established that while chloroform exerts a depressing influence on the heart, ether exerts a stimulating one, and that chloroform is the most dangerous.*"

Fig. 1.

Fig. 2.

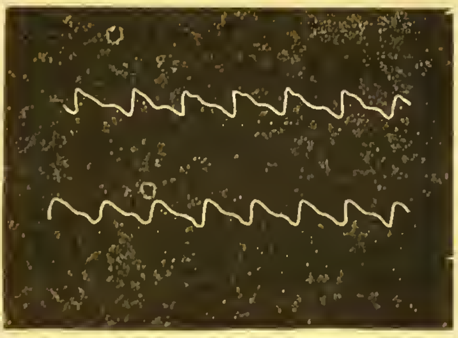

Fig. 1 represents the pulse of a female patient, aged twenty-five, who had been confined to bed for five months; pulse writing taken before etherization.

Fig. 2 represents it during its full influence. It will be seen that the heart power indication was rather stronger during etherization than before.

* The Dangers of Chloroform and the Safety and Efficiency of Ether, etc., by J. Morgan, M. D., F. R. C. S., Professor of Surgical and Descriptive Anatomy, Royal College of Surgeons, Ireland, etc. London, 1872, p. 28.

Fig. 3.

Another instance of a female, aged seventeen, also long confined in bed. The contrast of fig. 3, taken before etherization, and of fig. 4, during profound etherization, is notable; the elevation of the pulse line showing the stimulating property of the ethereal influence.

Fig. 4.

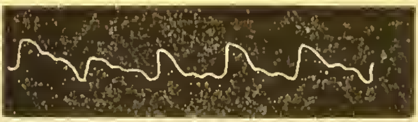

Fig. 5.

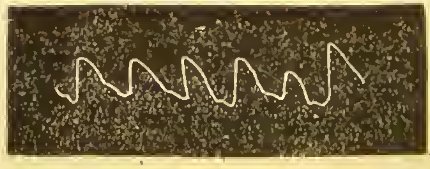

Fig. 5 represents the excited pulse writing of a small and nervous female, previous to etherization and operation.

Fig. 6.

Fig. 6 represents the pulse writing of the same patient when steadied by etherization. The contrast is remarkably favorable.

Fig. 7.

Fig. 7 represents the pulse writing of a healthy young man, of twenty-two, previous to operation for artificial pupil; an affection which had not interfered with his general health.

Fig. 8.

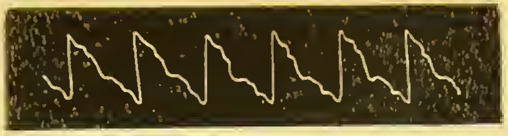

Fig. 8 represents the same when taken under full etherization, and after the completion of the operation. A comparison of this pulse writing with that of the natural soft pulse will be ample evidence of the safety of etherization in its action on the heart.

ALLEGED DANGERS WHICH ACCOMPANY THE INHALATION OF THE VAPOR OF SULPHURIC ETHER.*

Had we space, we should be very glad to copy the whole of this able pamphlet, but we must be content to give the conclusions which accompany it. We had, before receiving it, copied from Dr. Taylor on Poisons all the cases reported by him; but we found, on carefully reading it, that his cases were included in the appendix to the report of the Boston Society. In justification of the conclusions arrived at by the committee, there are presented in this report forty-one cases, gathered from every available source up to the year 1861, the date of publication.

"The general conclusions which have been arrived at by your committee may be summed up as follows:—

"1st. The ultimate effects of all anæsthetics show that they are depressing agents. This is indicated both by their symptoms and by the results of experiments. No anæsthetic should, therefore, be used carelessly, nor can it be administered without risk by an incompetent person.

"2d. It is now widely conceded, both in this country and in Europe, that sulphuric ether is safer than any other anæsthetic, and this conviction is gradually gaining ground.

"3d. Proper precautions being taken, sulphuric ether will produce entire insensibility in all cases, and no anæsthetic requires so few precautions in its use.

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* Report of a Committee of the Boston Society for Medical Improvement on the Alleged Dangers which accompany the Inhalation of Sulphuric Ether, pp. 36. Boston: David Clapp, 331 Washington Street. 1861.

"4th. There is no recorded case of death, known to the committee, attributed to sulphuric ether, which cannot be explained on some other ground equally plausible, or in which, if it were possible to repeat the experiment, insensibility could not have been produced and death avoided. This cannot be said of chloroform.

"5th. In view of all these facts, the use of ether in armies, to the extent which its bulk will permit, ought to be obligatory, at least in a moral point of view.

"6th. The advantages of chloroform are exclusively those of convenience. Its dangers are not averted by its admixture with sulphuric ether in any proportions; the combination of these two agents cannot be too strongly denounced as a treacherous and dangerous compound. Chloric ether, being a solution of chloroform in alcohol, merits the same condemnation."

INFLAMMABILITY OF ETHER.

Two accidents have come to our knowledge in which the ether was ignited, and, although causing no actual injury, produced much fear and confusion. The first was where a bottle of ether was accidentally broken and ignited while Dr. William Hunt was operating, during the night, at the Pennsylvania Hospital. The second occurred while Dr. William H. Pancoast was applying the actual cautery to a patient at the Jefferson College Hospital clinic during the day. Dr. Bigelow,* of Boston, in commenting upon the inflammability of the vapor of ether, observes, "Its practical safety is doubtless partly owing to the fact that the air, cooled by its evaporation, establishes a downward current." This is due to the greater density of ether *vapor*, for whilst the ether itself has a specific gravity of .728, its vapor has 2.568 for its specific gravity; and this fact may be readily noted by observing the downward currents of vapor when pouring from one bottle to another.

By combining the statistics collected in the United States by Dr. Andrews, of Chicago, and those of England by Dr. Richardson, of London, we obtain the mortality caused by ether (up to 1872), such as four deaths in 92,815, or one to 23,204.

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* Boston Medical and Surgical Journal.

Dr. C. Dawson,* of Leeds, England, has furnished the following list of deaths from ether from 1873 to 1877, and I have added those of 1878:—

TABLE OF DEATHS FROM ETHER, BY CAWTLEY DAWSON, L. R. C. P., M. R. C. S.; LEEDS.

The following analysis of the reports of deaths under ether is drawn up, not with the intention of comparing them with those under chloroform, it being assumed that the former has fully established itself as by far the safer anaesthetic, but with the object of gathering all the information they afford, and learning, if possible, all the preventable dangers, so as to improve the results. If we are satisfied that, although the percentage of deaths from ether is apparently below that of deaths from chloroform, we can yet improve by experience, and help to raise still further, though in a small measure, the science of anæsthesia towards the high standard of perfect safety which, we trust, is its ultimate position, it is not enough that we read reports of fatal cases at the times they appear in our journals, but we must again and again recall them, place them side by side, compare them with one another, and so scrutinize their every feature with untiring zeal, that, if possible, we may trace certain marks running throughout them, and become so intimate with those marks as to be able to recognize their earliest appearance or prevent their appearance altogether.

The above table includes, in the last five years, all, or nearly all, the deaths that have taken place in this country under the administration of ether; yet when we find them alone amounting to thirteen, though that number compares well with the number of deaths under chloroform, we feel that either we are not perfect in the art of its administration, or it is not the absolutely safe anæsthetic that we have been repeatedly told it is.

Let us examine the essential features of these thirteen deaths, together with five others that are reported in the same journals to have occurred in America, and compare the eighteen cases with each other.

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* See British Medical Journal, March 2d, 1878.

1. A woman, aged 45, was to be operated upon for fatty tumor on the back, at the West London Hospital on Feb. 18th, 1873. Chloroform was first given on lint, and, the pulse becoming irregular, ether was substituted. It became full and regular again, but suddenly stopped, the face at the same time being "dusky red." The ether used was pure; its specific gravity .700. One ounce of it was given; it was administered on a sponge in the apex of a cone made of felt, the sponge having been previously wrung out in warm water. The *post mortem* examination revealed nothing to account for death; all the organs were fairly healthy, except both lungs being gorged with blood.

2. An old patient had a cancerous submaxillary gland successfully removed under ether. Shortly afterwards, confusion and stupidity were observed, which deepened into unconsciousness with local convulsive seizures, and death supervened forty hours after the operation. The *post mortem* examination showed nothing to account for the mental symptoms. The chest was not examined.

3. S. S., aged 62, was to be operated upon at the Women's Hospital, in Birmingham, for ovarian tumor. After about five drachms of ether had been administered, she became satisfactorily unconscious, but suddenly appeared to revive, opening her eyes, and passing urine; the pupils were largely dilated, and the pulse could not be felt. Some subjective efforts at respiration were made, but they ceased, and Silvester's method of artificial respiration and other means of resuscitation were adopted without avail. At the *post mortem* examination, the cavities of the heart were found to contain a small quantity of dark blood; the other organs were healthy, except the ovaries and uterus; the state of the lungs is not reported. The anæsthetic used was a mixture of McFarlane & Co.'s anhydrous ether, and Hearon, Squire & Frances' bichloride of methylene.

4. David Newman, aged 14, had iridectomy performed for corneitis. Ether was given in a cone of spongio-piline. Before the operation was commenced, alarming symptoms presented themselves—great struggling, opisthotonos, and feeble pulse. The administration of ether was discontinued; the pulse improved, and the operation was performed. Afterwards, the pulse and breathing stopped altogether, and

the patient died. The *post mortem* examination showed the right cavities of the heart to be full of dark fluid blood, the left nearly empty, and the lungs congested with bright red blood.

5. An old man was etherized by Mr. McGill, of Leeds, in 1873, and operated upon for hernia. Wild delirium set in afterwards; the patient tore off the dressings, opened the wound, and tore out some of his intestines.

6. J. F., aged 16, was etherized for operation upon diseased bone in the hand on April 3d, 1875. Four drachms of Robbins' ether were poured upon some lint in a folded towel. The patient inhaled it rapidly, with no cough and with very little struggling. In four minutes he was ready for operation, when respiration suddenly ceased, the face became pale, the pupils dilated, and the pulse imperceptible. At the *post mortem* examination, the heart was found not to be weak, and the lungs not congested.

7. On January 23d, 1875, a man was placed under ether at the Cancer Hospital, London. He was thin and pallid, yet moderately healthy. Partial insensibility was first obtained by nitrous oxide; then ether, of the *British Pharmacopœia*, and specific gravity .735, was given in a cone of lint covered with oiled silk. After a slight struggle, the patient got under its influence. In five minutes the face became dusky, the respiration shallow, a gurgling sound in the throat was heard, and an effort was made to expel blood; the pulse, however, remained remarkably good. Breathing ceased, though Silvester's method was tried; and still the pulse kept beating for some minutes. At the *post mortem* examination, the *general* blood was found dark, fluid, and containing bubbles like those of air. The lungs were fully inflated, and grey. The right auricle was collapsed, and the ventricle empty; the left ventricle nearly so. A clot of blood was found in the trachea.

8. A patient at the Homœopathic College, New York, was etherized for operation upon a necrosed jaw. The pulse was watched all the time by another physician. The face suddenly became blue, and the respiration ceased.

9. The *Chicago Medical Journal and Examiner* related a case of the Charitable Eye and Ear Infirmary in Illinois. A man, aged 74, was operated upon for cataract by Dr. Holmes.

The patient inhaled the ether quietly till half a pound had been used; when a violent coughing commenced, which was followed by extreme lividity of the face and cessation of breathing. The ether was discontinued, and, by appropriate means, respiration was reëstablished; the lividity partially disappeared, and the action of the heart became stronger. Without any more ether, the operation was concluded. Again the patient ceased to breathe; the face became more livid and the pulse very weak till death ensued, in spite of renewed efforts to avert it.

10. The *Boston Medical and Surgical Journal* gave the particulars of a case in which Dr. Sinclair incised the os uteri for dysmenorrhœa. The patient had been a teacher. She was operated upon at a private hospital on July 19th, 1876. The ether was given on a towel, and, when the patient became unconscious, the doctors present, wishing to be engaged with the operation, entrusted the continuance of the etherization to a female. When they turned their attention again to the patient's condition, the breath and the pulse were found to have ceased. At the *post mortem* examination, engorgement of the pulmonary artery was found.

11. On September 15th, 1876, a man, aged 28, had his right leg amputated for compound fracture, at Guy's Hospital, by Mr. Howse. The house-surgeon began with chloroform; and, when the patient was completely under its influence, substituted ether. After the operation was finished, and as the effects of the ether were passing off, retching came on, and the pulse became feeble. *A little brandy was given.* Almost immediately afterwards, the patient began to vomit and became blue in the face. A large piece of undigested meat was removed from the back of the mouth; still no air entered the lungs; other pieces of food were removed from the entrance to the larynx with no better results. Tracheotomy was performed, and artificial respiration and other means were attempted; but the patient died. At the *post mortem* examination, the larynx and trachea were found full of partially digested food.

12. The *American Journal of Medical Science* for October, 1876, reported a case of death after ether. The patient, 19 years old, had contracted chest and lungs seriously restricted by adhesions, which bound them down in all directions.

The ether was administered for twenty minutes; death followed about two hours afterwards. At the *post mortem* examination, bronchial mucus, pulmonary and pleural serous effusion, were found.

13. The *Boston Medical and Surgical Journal* reported another case of death under ether. It was of an old woman in whom cerebral hæmorrhage was afterwards found.

14. A man, aged 69, was etherized by Clover's apparatus, for strangulated hernia, at the London Hospital. He commenced by inspiring only his own expired air for about thirty seconds; then he had the ether given in the proportion of from a quarter to a half for a minute. He struggled, and breathed the ether badly; the mouth-piece, therefore, was frequently removed from his face. The amount of ether was diminished, and, as his lips were blue, it was entirely discontinued; his breathing improved a little, but was not quite satisfactory. The pulse became weaker and weaker, and finally stopped; respiration, however, continuing for thirty seconds or more. At the *post mortem* examination, the heart was found flaccid, the left ventricle uncontracted, the lungs extremely emphysematous, the bronchi filled with mucopurulent matter, and other morbid changes were seen.

15. A patient, aged 56, had to be operated upon for a syphilitic caries of the leg, at the East Suffolk Hospital. Bichloride of methylene was first administered; and, as the patient did not readily succumb, methylated ether was substituted. The patient soon became unconscious; but, recovering unduly quickly, the bichloride of methylene was resumed. Great struggling and peculiar epileptiform convulsions ensued, followed by tonic spasm; this spasm relaxed; the breathing became stertorous; the pulse failed; and death supervened. There was no *post mortem* examination.

16. At the Moorfields Hospital, in August, 1867, a very stout woman, aged 46, was to be operated upon for cataract. A modification of Clover's apparatus was used; forty minims of chloroform were added to the ether to prevent the choking sensation. The reporter of the case proceeds to say: "She had only breathed the mixture for one minute, when the face became livid, and she could, therefore, hardly have been under the influence of the anæsthetic. The pulse and respiration continued fully four minutes after all anæsthetics

had been discontinued." The anæsthetic had been applied on and off for some time after the first alarm. At the *post mortem* examination the heart was found flaccid and empty; the mitral valve contracted; the walls in a state of fatty degeneration; the lungs emphysematous, and congested with blood.

17. Dr. Robert Saundby gave ether with Ormsby's inhaler to a case at Birmingham on October 4th, 1877. M. C., aged 35, had contracted knees. At 12.45 P. M. ether was commenced; only an ounce was used. There were no alarming incidents; very little stertor; no cyanosis; and the respirations were regular and full. Afterwards, the patient was carried out of the theatre across an open court for fifty yards, though well wrapped up. At 2.45 P. M., one hour and a half after leaving the theatre, the patient suddenly became alarmingly ill, cyanotic, and pulseless. *Râles* were heard over the chest. At 4.15 P. M. he died. At the *post mortem* examination, œdema was found in the membranes of the brain; no thrombus in the pulmonary artery; the heart was healthy, containing a little blood in the right auricle; the ventricles were contracted; the lungs were pale and œdematous; the other organs were healthy. The ether used was of the specific gravity 720 722.

18. At Lincoln, Miss S., aged 45, was etherized by Dr. Mitchinson for an operation upon a cancer of the breast. *Half an ounce of brandy was given first.* At three o'clock, pure sulphuric ether was administered by means of an inhaler, formed of a bag of muslin covered with a leather case, which had a valve at the apex and a larger one at the lower edge; the valves were open, and air was allowed free ingress and egress. Another doctor's finger was on the pulse of the patient all the time. Half-an-ounce having been poured into the inhaler, Dr. Mitchinson held it lightly over the patient's face; immediately, she spoke as if half unconscious, and with two more inhalations became turgid about the face, and her hands pinched and white; there was no pulse. The tongue was dragged forward, and several forcible inspirations resulted; they, however, became less and less till 3.15, when she died. At the *post mortem* examination, the heart was found covered with fat; the right ventricle contained an ounce of fluid blood, the left was firmly contracted and

empty; the muscular coat was one-twelfth of an inch thick. The base of the right lung contained a considerable quantity of fluid blood, and the base of the left a smaller quantity; there was cancerous deposit in both lungs.

The following eighteen cases, which show, *primâ facie*, their causes and modes of death, may be at once taken out of the list, viz.:—

No. 2, the old man, who, after the anæsthetic effects of ether had passed away, had not the strength to rally, but passed through the stages of confusion, stupidity, unconsciousness, and coma successively within two days.

Nos. 3 and 15, the ether being in the one case mixed with, and in the other replaced by, bichloride of methylene.

No. 5, in which Robbins' ether was used, for Dr. Richardson says it is not pure ether, but a mixture of amyl hydride and anhydrous ether; it is useful in producing local anaesthesia by the spray-machine for which it is manufactured, being of a low boiling point and specific gravity, and it is directly dangerous when inhaled.

No. 11, in which the trachea was found filled with food.

Nos. 12 and 14, where previous pulmonary trouble was just aggravated by means of the ether.

Nine cases still remain, in which ether appeared to play no secondary part, nor even to be assisted by any untoward condition or circumstance; and the question immediately follows: What killed these patients? They who admit that, although ether is safer than chloroform, it is not absolutely safe, answer "asphyxia;" whilst all others, including those who assert the absolute safety of ether, give no answer at all.

It may be an advantage to draw up the essential particulars of these nine cases in a table, so that we may the more readily compare them altogether, and consider the following points:—

A. The important *facts* reported in these cases.
B. The probable conclusions deduced from the facts.
C. A theory explaining the facts and the deductions.
D. The best method of the administration of ether.

TABLE OF NINE CASES OF DEATH UNDER ETHER.

No.	Kind of Ether.	Instrument Used.	Quantity Used.	First Alarming Symptoms.	Time between Commencement of Alarm and Death.
1	Pure; sp. gr. .700	Warmed sponge in felt cone	One ounce	Face dusky red; pulse stopped	Query? * *
4	* *	Spongio-piline cone	* *	Opisthotonos, and pulse feeble	The operation performed in the interval
7	B. P.; sp. gr. .735	Lint cone covered with oiled silk	The inhalations during five minutes	Face dusky; respiration shallow; pulse good	Some length of time
8	* *	* *	* *	Face blue; respiration ceased; (pulse good?)	Ditto ditto
9	* *	* *	* *	Face livid; respiration cease; pulse weak	The operation performed in the interval
10	* *	Towel	lb. ss. on a towel; part lost in air	* *	* *
16	* *	Modified Clover's	Inhalations during one minute.	Face livid; respiration and pulse continued	Four minutes
17	Sp. gr. .720-2	Ormesby's inhaler	One ounce	Face cyanotic; pulseless; râles	From 2.45 P. M. to 4.15 P. M.
18	Sulphurised	Leather case with valves	Half an ounce, but only three inhalations	Face turgid; pulseless	From 3.00 P. M. to 3.15 P. M.

"POST MORTEM" APPEARANCES.

No.	The Lungs.	The Heart.	Other Organs.
1	Gorged with blood	* *	
4	Congested with bright red blood	Right side full of dark fluid blood; left side empty	All healthy
7	Trachea contained a clot of blood	Right auricle collapsed; ventricle empty; left nearly so	
8	* *	* *	
9	* *	* *	
10	Pulmonary artery engorged	* *	
16	Emphysematous and congested	Flaccid; fatty walls; mitral valve contracted	
17	Pale and œdematous	Right auricle contained a little blood	Healthy
18	Bases contained considerable quantity of blood	Right side contained one ounce of dark blood, left empty; walls a twelfth of an inch thick	Cancerous deposits

* * In the spaces of those cases where the double asterisks are placed, the reports gave no details to put in. Nos. 8 and 9 being shortly reported from American journals, many of their details are wanting.

A. *The important facts.*—They are easily recognized in looking over the table of the nine cases.

1. Ether was inhaled in various yet limited quantities, from three inhalations of it up to as many as would consume half-a-pound on a towel; and then produced the symptoms ending in death. It was diluted with various quantities of atmospheric air, and given in various methods.

2. The face was reported to be "dusky," "blue," "dusky red," "livid," "cyanotic," or "turgid" in seven of the nine cases, and never said to be "white" or "pale;" in the other two, the color is not reported at all.

3. In seven cases the heart did not cease till some time had expired after the commencement of the alarming symptoms, and after the ether had been discontinued; the intervals varying from four minutes to three hours. In those of which the notes were comprehensive, we read that the pulse remained feeble, weak, or good, for a longer or shorter length of time after the ether had been discontinued, or after the alarm had been taken; in the other two cases, no certainty on that point can be gathered.

4. The lungs were reported to have been gorged with blood in five cases, and the pulmonary artery in the sixth. In another, the trachea contained a clot of blood; and, of the remaining three, two cases were not reported at all, and one case only (No. 17), in which the patient died three hours after the ether-inhalation was over, were the lungs altogether "pale," and even then they were "œdematous."

B. *Two Deductions* seem to follow from these facts.

1. The fatal effects of ether do not depend upon any directly poisonous property of its own.

2. These cases died by "asphyxia."

Is not the former deduction indicated by the facts that the quantities of ether given in these cases were various and often small, and the proportions of its mixture with air, as well as the methods of its administration, also various? And is it not further borne out by the experience of so many cases in which ether has been given in large quantities with the smallest possible amount of atmospheric air, and still the patients have to all appearances been perfectly safe?

Some cases might be quoted, such as those which caused

men like Dr. Joy Jeffreys to affirm the belief of American surgery that ether is absolutely safe; but one will suffice. Mr. Furneaux Jordan related a case in which the ether was pushed to an extreme degree, on account of the marked and uncontrollable tremor of the muscles rendering the operation doubly difficult. The anæsthetiser, Mr. Priestley Smith, when requested by Mr. Jordan to give the patient more ether, remarked "that the man was as much under the influence of ether as it was possible to effect."

The second conclusion, that asphyxia was the mode of death, is, to my mind, irresistible from the dusky face, the shallow respiration, the interval between the commencement of the alarming symptoms and death, the engorged lungs, and other signs reported in most of the cases.

C. *A Theory explaining these facts and reconciling these conclusions.*—The intense cold produced by the ether under certain circumstances causes the small blood-vessels of the lungs to contract, and so offer such degree of resistance to the right ventricle of the heart as to stop it, if it be weak or wearied, and embarrass it, if it be strong; and, by watching the symptoms from this point of view, we are likely to be able to cope with the dangers as they may arise, or even (may we hope?) to prevent their occurence entirely.

Assuming that the deductions under the head B are logically based upon known facts, we are driven into a corner out of which only such a theory as this can help us.

The asphyxia by which these deaths occur cannot be said to be brought on by any interference with the nerves or nerve-centres directly concerned in respiratory movements, *i. e.*, by paralysis of respiratory muscles, like the asphyxia from carbonic dioxide poisoning; nor, on the other hand, by any mechanical interference with the air-passages, as the asphyxia from hanging or drowning; but must be from interference with the chemical process of the aëration of the blood in the air-cells and blood-vessels surrounding them. This interference is not due to the want of oxygen, because *none* of these cases show that oxygen was absent; but most of them show the reverse, pure atmospheric air having been breathed for some time before death. It must, then, be the result of the insufficiency of the circulatory action of the

blood, in the capillary vessels of the lungs, to do their share in carrying on respiration. What obstructs this circulation? It cannot be that the blood is poisoned with ether; for, in one case (No. 18), three inhalations only had been taken, and in another (No. 16) the ether had been administered for one minute only. It must be from some property of ether which comes into action in certain circumstances; and, when we call to mind its power of producing intense cold under some conditions, we venture to inquire into the likelihood of that property being the cause of asphyxia. Suppose it to be true. Ether, in its administration, becomes a vapor by absorbing a fixed amount of heat from surrounding media, generally the atmosphere, and in that condition is inhaled into the larger bronchial tubes, and then becomes mixed with the residual air in the smaller tubes and alveolar spaces. From them it is absorbed into and dissolved by the blood, becoming a fluid again virtually in that act, and therefore giving off a certain amount of latent heat. This heat diffuses itself through the body as well as the ether, and probably much faster, the latter having to be pushed on to other parts by the continued addition of more ether behind. This process goes on as long as ether is added. When its administration is discontinued or interrupted for any reason, and pure air allowed to enter the lungs, the current of osmosis between the blood in the capillaries of the lungs and the contents of the air-cells is reversed. The ether, having now to change from the state of fluid to that of vapor again, reabsorbs the amount of heat it gave off on its entrance into the blood. If the air which has just entered the lungs be warm, the abstraction of heat for the reëvaporation of the ether will not be felt by the lungs, though it is sudden and local; but if, on the other hand, that fresh air be cold, whether on account of its passing through or close to an ice-cold instrument, rendered so by the action of the ether, or from the room being cold, or from the patient having been put into a cold place, though well wrapped up, the amount of heat required suddenly by the ether on its returning to the atmosphere will be more; and the lung-tissue, not having stored up the heat, the ether brought to it will, upon this sudden demand, become so cold as to cause a violent contraction of its arterioles. Such

an amount of obstruction, from this contraction of a large number of vessels, without anastomoses or diverticula, resists the right side of the heart; that, unless the latter has an immense margin of strength, failure in its function is the result, and the patient dies in a space of time varying with the amount of resistance and the amount of strength the right ventricle possesses. If the death were rapid, there would be engorgement of the main branches of the pulmonary artery and the right side of the heart. But the heart may be able to overcome this obstruction; then the capillaries of the lungs become engorged, the chemical process in respiration becomes impeded, and the *vis a fronte* more or less lost. Here is another and, perhaps, greater resistance to the heart; and the latter, wearied out now, might fail. In this case, death would be more delayed than in the former; the pulse might be felt to become more and more feeble. Afterwards the lungs would be found engorged with blood, and the right side of the heart might be full of dark blood, or the reverse.

But a strong heart might be supposed to overcome even this second resistance; then the engorged capillaries would throw out a quantity of serum into the air-cells and the surrounding tissues; that in the air-cells becoming frothy and being expectorated; that in the tissues, perhaps, after some time becoming reabsorbed, or possibly causing so much difficulty in the acts of respiration as to constitute the last straw and break the camel's back, by offering such embarrassment to the exhausted heart that the patient at last succumbs.

D. *The Best Method of the Administration of Ether.*—My own experience consists principally in having administered anæsthetics for Mr. Pridgin Teale's cases in private, with very few exceptions, during the last year and a half. In those cases, except with very young children, ether has nearly always been administered. At first we used the sponge, covered with mackintosh; then the American framework, with the bandage weaved in it; next, Clover's larger apparatus; lastly, Clover's smaller and more recent inhaler. I have also used Ormsby's inhaler a few times.

In my opinion, Clover's smaller inhaler is the best; it is made by Meyer & Meltzer, Great Portland Street. It is

composed of an ether chamber and water chamber, together in a circular vessel; a bag that can be detached; and a face piece, which likewise can be detached, and which rotates, when fixed to the vessel, for the purpose of regulating the amount of ether-vapor; it has no valves or sponge. It possesses the following advantages:—

1. There is no struggling or resistance on the part of the patient, however terrified or prejudiced he may be; the ether being invariably breathed with comfort, and in many cases with even a sense of pleasure.

2. The amount of ether-vapor can be carefully regulated to a nicety without lifting the machine from the patient's face, and, consequently, it is easy to keep a patient on the very borderland of insensibility for any length of time.

3. The ether being economized, and not being dissipated into the surrounding atmosphere, there is not only a better chance of fresh air if needed for the patient, but there is more comfort to the operator and his assistants, and especially to the anæsthetiser, who, with other contrivances, often inhales a large share of the vapor himself, and in consequence suffers many a headache. There is also a considerable saving of ether; an ounce and a half usually being sufficient for half an hour, when formerly eight, nine, or more ounces were used.

4. There is none of that bronchial mucus which gave, with other instruments, so much trouble at the time of inhalation, and which was often followed by bronchitis, and in some instances by death.

5. When consciousness has so far returned that the patient can recognize, and even speak sensibly, the sensibility to pain is still so numb that an operation may be concluded, sutures put in, and dressings applied, without the slightest sign of pain from the patient.

6. The comfort to the patient, silencing his resistance and calming his mind, the ease with which the anæsthetiser can administer and regulate the ether without the distraction caused by the patient's struggles, or the etherized atmosphere, or the repeated application to an ether-bottle for fresh supplies, and the equable temperature at which the ether-vapor can be kept, combine together to insure the greater safety to the patient.

The following are the details of the method of administering ether with the above-mentioned machine which I have adopted, keeping in view and acting upon the theory spoken of under the division C of this paper; and Mr. Teale expresses himself well satisfied with the practical results that continue uninterruptedly under his observation.

1. Never allow any solid food, milk, or spirits to enter the patient's stomach for six hours beforehand.

2. See that the room is well warmed.

3. Detach the bag and face-piece from the metal vessel of the machine; warm the vessel by placing it in a basin of hot water an inch deep; pour an ounce and a half of methylated ether, specific gravity .714, into the ether-chamber; put the face-piece to the vessel, and rotate it so that the indicator points to "no ether." Let the patient breathe through the vessel without the bag into the air, so that he gets only a flavor of the ether; his nervousness and fear will by this means be soon allayed, and confidence gained. Avoid giving him the choking sensation until he becomes numb to the ether; by giving him the ether slowly at first, imperceptibly and gradually increasing it, the bag being placed to the vessel, and so stealing over his sensitiveness until he is quite "numb;" then proceed rapidly to full ether, without any atmospheric air. Watch the respiration closely: if it be at all embarrassed, give one breath of fresh air, and resume the ether, at first weak, but increase it as before. He will soon be under its influence; then reduce the proportion of ether by the regulator, so as to keep him just beyond the boundary line of sensibility; give him one breath of fresh air occasionally. Continue to watch the respiration closely. After the operation, do not place the patient suddenly into a cold room or passage, even if he be warmly clothed.

DEATHS UNDER ETHER.*

A coal porter, over fifty years of age, was admitted into the London Hospital for strangulated hernia. Taxis having been used, and the symptoms unrelieved, the house-surgeon administered ether, using not more than an ounce and a

* British Medical Journal, May 18th, 1878.

half in all; the patient came under the influence rapidly and without difficulty. The local examination was then proceeded to, with respiration regular and pulse good. About six minutes after the inhalations began, a sudden spasmodic inspiration was heard as if he were choking. His tongue was drawn out, but respiration had ceased, although his pulse continued to beat for another half minute. Silvester's artificial respiration was employed, but no spontaneous inspiratory effort followed. During the artificial respiration, some fœcal matter came up into the mouth.

At the post-mortem, the left ventricle was found contracted; heart healthy. The lungs were extremely congested. There was fœcal staining of the œsophagus and larynx, but no such matter had been drawn into the lungs. The kidneys were granular.

G. W. Callander, Esq., stated to the writer that just prior to his leaving London for a visit to the United States, a death took place at St. Bartholomew's hospital on the administration of ether (kind of ether not known, but what is usually employed in England, which is a mixture of two or three ethers). This death took place prior to any operation; the man had been received into the hospital for an intestinal trouble.

REMARKS ON DR. DAWSON'S THEORY.

We cannot agree with the Doctor that the cold has anything whatever to do with the fatal results, as we have never found the skin or pulse to fail under ether until the inhalation had stopped; then the skin became moist, clammy, and cold; and, if exposed, collapse of the lungs. If the system is not able to remove the moisture from the skin, the lungs must suffer, and the patient dies.

In many persons, the lungs contain so little residual air, that the ether-vapor fills them almost entirely, not only depriving the blood of its required oxygen, but also producing its special influence upon the brain and nerves of sensation and motion. It is true that no apparatus now at our disposal entirely prevents air from reaching the lungs; but the great difficulty lies generally in the sponge or towel used becoming so wet with the watery vapor, that a perfectly air-tight covering for the mouth and nose is formed, neces-

sarily producing asphyxia if left too long. Ether, like water, may also fill the trachea, preventing the air from reaching the lungs, as often noticed in drowned persons, the trachea being found full of water; undoubtedly the prime cause of death.

We have a beautiful exemplification of the action of the oxygen of the air in the human body, in the elimination of poisons in the transient operation of moderate doses of alcohol, ether, chloroform, opium, strychnia, prussic acid, snake poison, etc., etc., in all of which the real question of life or death is one of *time;* for if the fatal results do not speedily follow the absorption of the poison (as in chloroform, strychnia, snake-bite, or prussic acid) into the blood, the patient gradually recovers from its effects, and the most effectual treatment consists in the maintenance of artificial respiratory movements. Ether always gives timely warning.

ETHER VERSUS CHLOROFORM.

Prof. Ringer (*Handbook of Therapeutics*, seventh edition, pp. 344, London, 1878) says: "Ether for many years preceded chloroform as a general anæsthetic. At the present time, there is in this country much contention as to the relative merits of chloroform and of ether; and *ether* bids fair rapidly to take the place of chloroform."

Pure sulphuric ether is, without doubt, the most perfect anæsthetic we possess for use by the physician and the general surgeon. The proofs of its safety are full and complete. In the city of Philadelphia alone it has been used, with but one exception, since its introduction in 1846, up to the year 1878. In these thirty-two years, at least from three to five times a day it has been employed by the nine hundred and sixty-seven regular physicians. These 11,660 days, multiplied by three, would give us 34,980 administrations without a single primary death, and only one recorded secondary death.*

If sulphuric ether is made from pure materials, and washed with care, it is superior to all other anæsthetics in its freedom from irritation of the stomach, and in protracted and dangerous operations, provided the usual caution is

* American Journal of Medical Science.

observed—*i. e.*, not to take any solid food, except a biscuit or cracker, with a glass of wine, or a small quantity of brandy or whiskey and water, for six hours prior to the inhalation.

To show that it can be used for the most delicate operations on the eye, it is stated by Dr. Carter, the distinguished ophthalmic surgeon of London, that he employs ether with perfectly satisfactory results in all operations on the eye as regards the spasm of the muscles, and without the appearance of any symptoms to indicate a possibly prejudicial action. This testimony is corroborated by all the ophthalmic surgeons of our city.

In our own experiments, where a small quantity of liquid food had been taken before the inhalation, the proportion of cases in which vomiting occurred was only one in fifty. Dr. David Webster, of New York, states, in his cases taken indiscriminately, and not adopting the important caution, "that vomiting occurred once in forty-two cases." In thirty persons etherized by the late Dr. J. Morgan, of Dublin, sickness of the stomach occurred in only two cases. In twenty-six reported by Surgeon-Major Porter with the ether made in England, by the action of sulphuric acid on alcohols made from potato and wood spirit, vomiting occurred in ten cases, owing to its impurities.

"Again, from the annual report of Professor Bardeleben's clinic in Berlin, for 1876–7, we learn that deaths from chloroform occurred in that year four times among twelve to fifteen hundred narcoses; in all four cases, a small amount of chloroform was used when death occurred. These accidents, as well as an exceedingly large number of troublesome narcoses, caused the Professor to abandon chloroform, and used chloral and ether. All narcoses have since been free from complications." *

LOCAL ANÆSTHESIA AND ANÆSTHETICS.

The method of local anæsthesia proposed by Dr. Benjamin W. Richardson is the one most generally adopted. The process consists in directing ether on a given surface of the body, the strongest, freed from alcohol and water, in minute

* Chicago Medical Journal and Examiner, October, 1878.

division or spray, mixed more or less with atmospheric air. This is accomplished by means of a hand-spray, an article which has become very popular in diffusing the various perfumed waters in a room. The apparatus consists of a bottle to contain the ether; through a perforated cork a double tube is passed, one extremity of the inner part of which goes to the bottom of the bottle; above the cork a tube connected with the bellows (a rubber bag) pierces the outer part of the double tube, and communicates by a small aperture at the inner end of the cork with the interior of the bottle. The inner tube for delivering the ether runs upwards to the extremity of the outer tube.

When the two rubber bags or bellows are compressed by the hand, a double current of air is produced; one current descending and pressing upon the ether, forcing it along the inner tube, and the other ascending through the outer tube and playing upon the column of ether as it passes from the inner tube.

RHIGOLENE,

A product obtained by the distillation of petroleum, is also used for local anæsthesia; it is the lightest of all known liquids, its specific gravity being .625; it boils at 70°. This local anæsthesia, which is produced by the evaporation of these volatile liquids, which produce intense cold, can be used with advantage in minor surgery. It should never, by these agents, affect a large surface; nor should it be long applied, else it will freeze and destroy the tissue, so that the death of the part may take place.

Dr. Letamendi* has discovered a new mode of utilizing the anæsthetic effects of ether-spray. After applying Richardson's spray-producer for about two minutes, in which he employs perfectly neutral sulphuric ether, the skin has by this time become red, and is the seat of a disagreeable sensation of cold, but no sensation of burning in the part. If at this moment an incision, eight to ten millimetres long, is made with a convex bistoury in the centre of the reddened part, not being carried deeper than the papillary layer of the cutis, immediately the incision is made there is suddenly

* Archives de Physiologie, November, 1875.

produced an anæmic zone, which enlarges outwards from the point incised.

If the spray is again directed for a few seconds on the part which has thus become anæmic, the region becomes perfectly bloodless and completely anæsthetic. The tissues, when cut, are like frozen fat, and have lost their elasticity. Around the white circle there is a zone, in which the anæmia is not absolute. The spray directed on this zone speedily makes the anæmia and consequent anæsthesia complete; the anæsthesia can thus be carried around or along a limb.

The theory brought forward by Dr. Letamendi to account for the effect of the slight incision is, that the cold produced by the ether causes relaxation, and consequently dilatation of the vessels. The incision produces a sudden reaction, which converts the extreme dilatation into extreme contraction. The practical advantage is, that anæsthesia is obtained without a prolonged application of the ether-spray.

ANÆSTHETIC MIXTURE.

℞. Sulphuric ether, f℥j.
Pulv. camphoræ, ʒiv.—M.
Dissolve.

On applying this mixture for a minute or two to the part where a superficial operation is to be practised, local anæsthesia is temporarily produced.

EXCISION OF CANCER OF THE BREAST BY SCISSOR-CUTTING UNDER ETHER-SPRAY, BY DR. BENJAMIN W. RICHARDSON.

"The nature of the tumor was sufficiently clear. It was a hard scirrhus, of the size of a small hen's egg, loosely held in the gland, with no adhesions to the muscular structure beneath. The family history of the patient confirmed the diagnosis; her mother had suffered from scirrhus of the breast. The diagnosis left no doubt respecting the proper mode of treatment; there could be no hesitation in advising that the abnormal growth, while it was yet easily movable and removable, should be excised, and to this advice the patient gave a willing assent. But now the question of the administration of an anæsthetic came under consideration. The action of the heart of this lady was so intermittent and irregular, and the power of her heart was so reduced, that

the slightest external impression influenced it in its motion; she belonged, in a word, to that population which is prone to die suddenly from chloroform and the other narcotic vapors. Under these circumstances, I proposed to the patient that the tumor should be excised under local anæsthesia; and, that the failure of the process, if failure should follow the recommendation, might fall upon me entirely, I performed the operation myself.

"I operated on the 8th of May last, in the following manner. The patient having been placed in a semi-recumbent position on a narrow couch, I directed Mr. W. Perkins, who very efficiently conducted the local anæsthesia, to direct gently over the tumor a large spray of common ether, so as to chill thoroughly, but not to freeze the skin. I let him maintain this for a period of five minutes, then I handed to him another tube and bottle for spraying over the already chilled part the light fluid called anæsthetic ether, a compound of ether of specific gravity .720 with hydride of amyl. A few moments' application of this lighter ether was sufficient to render the whole of the breast frozen like a hard snowball; for a minute longer, that the deeper structures might become equally chilled, the spray was continued. When the structures were thus prepared, instead of using a scalpel for cutting, as in the ordinary way, I made the required incisions through the skin with a pair of small, strong, sharp, slightly-curved scissors. Commencing the incision by an angular cut at the outer margin of the part to be excised, I carried the lower blade of the scissors deeply into the breast, with the edge of the blade everted; in this way I cut the lower flap; then, commencing at the same angle, I cut in the same manner the upper flap. The rapidity and ease with which these incisions through the hardened tissues were made, struck me most favorably; the incisions were deep enough to enable me to grasp the tumor firmly with the left hand. I now laid down the ordinary sharp-cutting scissors, and with a pair of strong, slightly curved, tooth-edged scissors, I proceeded to cut on each side of the tumor until I could fairly lift it up; then, by a few strokes made with the same scissors underneath, I cleared it completely away. The operation lasted precisely three minutes, and was unattended, during the whole time, by the escape

of blood. The diseased mass removed, I had the ether-spray withdrawn, in order to see if any vessels would bleed during reaction from the freezing; there was a little oozing of blood, which quickly subsided, and one artery was tied, both ends of the ligature being cut off close to the vessel. The wound, carefully cleaned with a soft, damp sponge, was closed; the edges of it were secured with five sutures; a pledget of cotton-wool, charged with styptic colloid, was placed over the wound; and a lint-pad and firm bandage completed the dressing. The patient passed a good night after the operation; she was allowed to rise and go into the drawing-room on the following day; and as she exhibited no rise of temperature beyond 99° F., and that only for a few hours, and suffered from not one untoward symptom, the dressing was left untouched until the 13th of May, when, on removing it, the wound was found healed throughout its entire extent. The sutures were removed a few days later, when the line of incision was found fairly closed, without a particle of discharge or interruption of healing at any point. During the whole of the operation the patient did not utter a single expression of pain.

"*The effect of the local anæsthesia.*—It is certain that in this case the local method afforded everything that could be desired in the way of anæsthesia. It saved all acute pain; it saved the patient the dread of death during the insensibility from a general anæsthetic, and it enabled me to proceed in our task without a thought as to the immediate safety of the patient. I may say more for it still: it warranted me in recommending the operation. I should certainly not have advised any friend of mine, whose heart was in the same condition of irritability and irregular nervous supply, to inhale an anæsthetic vapor, to the fatal effects of which such conditions of the circulation are so favorable. Applying, then, this same rule to a patient, who in putting his life into my hands makes his life for the time mine, I should consider it actually wrong to recommend a risk I would not myself accept; but, taking advantage of the local method, I had no occasion to suggest a danger of any kind, while I secured my patient the benefits of anæsthesia. I saved her the dread of death from the effects of a general anæsthetic; I saved her pos-

sibly the symptoms of after-vomiting and faintness; and I saved myself and my colleagues, during the operation, the anxiety that ever attends the administration of a general anæsthetic to persons in whom disease of the heart is foreknown.

"*The method of cutting with scissors.*—Local anæsthesia has many disadvantages; it is more troublesome than general anæsthesia as a detail of practice; and, as it leaves the consciousness alive, it fails at times in preventing the fears of the patient. But hitherto the greatest difficulty in operating under it, has been the obstacle of cutting through the hard, frozen, insensible part; the resistance to incision by the best cutting knife, and especially to dissection by the knife, is such that I have seen the most skillful surgeons troubled by it; and I have never been able to complain of the objection that has been made to the method on this ground. The difficulty is now overcome by the process of scissor-cutting which I have here introduced. The advantage of the scissors over the scalpel will be at once proved by any one who will take a thick, firm structure, the cover of a book, for example, and try to cut through it; with the best of scalpels he will be troubled, but with scissor blades he will cut with the utmost facility, if the blades be well set. So, in cutting through the frozen animal tissue, the parts can be divided as rapidly as may be wished with the scissor blades, with perfect accuracy of incision, and as deeply as may be desired; the cutting is also made without any downward pressure, by which pain of pressure is saved; also in deep dissection the tissues, frozen as they are exposed, can be divided more easily than by the knife, for the harder they are solidified the easier they are divided by the scissor blades. In a word, I believe that every cutting operation, in which local anæsthesia is practicable, may be performed neatly and effectively by scissor-cutting, and that a much larger number of operations may now be painlessly carried out under the local method.

"Some little attention requires to be paid to the instruments used. The scissors for superficial or skin cutting should be exquisitely sharp, neat, and strong; and I prefer them slightly curved. For deep cutting, where there are many blood-vessels, the tooth-edged cutters are valuable;

these pierce, crush, and divide at the same time, and they save blood. For other purposes, as for division of a sinus, some modifications are required, and Messrs. Krohne & Sesemann are now making for me a case of instruments for the special purpose of operation in the method under consideration.

"*Effect of the operation, on the heart, in the case related.*—No fact is more instructive in the history of the patient recorded in this paper, than the beneficial effect produced on the functions of the heart by the operation. In this instance, the cardiac irregularity and irritability were purely due to irregular nervous supply, to nervous irritation and consequent muscular exhaustion. The irritation might have been in part due to the mental anxiety which naturally accompanies the disease, or it might have been due to the irritation of the tumor, and have been reflex in character. Whichever view be correct, the result of the operation was curative; and, as the case is typical of a class of phenomena of disease, the lesson it teaches is extended far beyond it as an individual illustration. It shows that so soon as the heart obtains rest from the persistent nervous thrill that invades it, its muscular tone returns, and its irregular motion and excitability cease. Thus by operating early for the removal of cancer, the surgeon acts as physician also, and prolongs the general life by removing the local disease. I am convinced I have seen patients suffering from cancer die from the mental and local irritation of the disease long before any development of the malady has advanced to kill by destruction of the part or organ involved; I infer, therefore, that if, without any danger to life from general anæsthesia, we can remove external malignant growths painlessly and promptly, so soon indeed as they are detected, we shall bring art, effectively, to the defeat even of cancer."*

* Prof. Billroth expresses himself as follows: "Local anæsthetics, which have for their object temporary blunting of the pain in the part to be operated upon, by application of a mixture of ice and saltpetre or salt, have been abandoned, or rather they have never been generally received. Recently these attempts have again acquired a general interest, as it seemed that a suitable method of local anæsthesia had at last been found: Dr. B. W. Richardson, by means of a pure spray blown against the spot in the skin, and such cold is here induced that all sensation is lost. After procuring some of this ether (hydramyläther) from England, I was satisfied of its perfect action. In a few

GASOLINE.

This is a new and cheap agent as a local anæsthetic, and will answer all the purposes of ether at one-fourth the cost.

Dr. C. J. Essig, in the *Dental Cosmos* for November, states that the following preparation has given uniform satisfaction as a local anæsthetic:—

℞. Pulv. camphoræ, ℨiv.
Etheris sulphuris, f℥iv.—M.

Sig. Apply to the gum, surrounding the tooth to be extracted, with a pledget of cotton, until the gums turn white, when the tooth can be extracted with very little pain.

INTERNAL ADMINISTRATION.

Exhibited internally, sulphuric ether is an excellent diffusible stimulant. It sinks in water, and is best administered mixed with spermaceti and sugar, or in mucilage of gum arabic; its taste is hot, pungent, and irritating, and when placed in the mouth, ears, nose, or rectum, pain is produced. It dissolves in alcohol, whiskey, or brandy; and when required as a powerful stimulant, as in fainting, exhaustion, or collapse, this is an excellent method for administering it. In using it for some time, it is best given enclosed in capsules.

Gout.—In sudden attacks of gout in the stomach or intestines, a useful mixture is the following:—

℞. Spiritus vini gallici,
Æther. āā f℥j.—M.

Sig. Dose, one teaspoonful in sugar and ice-water, repeated until relief is afforded.

This same preparation will be found valuable in *spasm of the stomach, or intestines, or heart.* Ether has been proved useful in *tape-worm*, alone or combined with the oleo-resin

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seconds the skin became chalky white and absolutely without sensation, but the effect hardly extends through a moderately thick cutis; and, if the ether be still blown against the cut surface, the frozen tissues cannot be distinguished from each other, and the knife, being coated with ice, will no longer cut. Hence, even in this most perfect form, local anæsthesia can only be used advantageously in a few minor operations. My former dread, that healing of the wound would be essentially interfered with by this freezing of the part, has been shown to be groundless."—Fourth German edition, translated by C. E. Hackley, A. M., M. D., New York, 1879, p. 21.

of the male fern. The patient must live upon milk and a little bread for one day, and the following morning, fasting, take the full dose:—

℞. Oleo resinæ Filicis, ʒss.
Æther. fʒj.
Mucilag. acaciæ, ad. ft. f℥ss.—M.

This is to be repeated in three hours; in the evening food can be taken, to be followed with a full dose of castor oil with twenty drops of spirits of turpentine. Some French authorities prefer to give fʒiss. of ether alone, administered at once, and followed in two hours by the purgative.

Ether is also one of our most potent remedies in *hysteria*, especially when associated with valerian, assafœtida, musk, or camphor. In the first with the fluid extracts, as follows:—

℞. Æther.
Valerian. ex. fluid. āā fʒj.—M.
Sig. A teaspoonful every hour.

In the second it is mixed with the tinctures as follows:—

℞. Æther.
Tinct. Assafœtidæ, āā ʒj.
Mucilag. acaciæ, ʒj.—M.
Sig. A teaspoonful every hour until relieved.

With musk:—

℞. Moschus, ℈ij.
Æther.
Mucilag. acaciæ, āā fʒj.—M.
Sig. A teaspoonful every hour.

With camphor, ether is not only useful in hysteria, but all forms of "*nervousness*" in *dysmenorrhœa*, *diarrhœa*, *cholera*, *abnormal sexual excitement*, *epilepsy*, *hysterical*, *puerperal*, *and strychnic convulsions*. Camphor with ether is best administered as follows:—

℞. Vitelli ovi, ʒij.
Pulv. camphoræ, ʒij.
Æther. ʒij.—M.
Add the ether to the camphor, and then the emulsion; administer in tablespoonful doses every two hours.

Cure of Sciatica by subcutaneous injections of ether.—Dr. C. G. Comegys reports, in the *Cincinnati Lancet and Observer*, the successful treatment of a case of sciatica by means of

hypodermic administration of ether, and that, too, after almost every other thing had been tried. He first gave fifteen drops, which was followed immediately by great pain, but which soon passed off. The injection, in increasing doses up to thirty drops, was repeated morning and evening for three days, when the patient was discharged cured. No local injury resulted; the injections were made in the ordinary superficial method, and not deep.

According to Zuelzer, ether can be used as a stimulant in small doses by hypodermic injections. He states that the symptoms of collapse are relieved by it, and abscesses are rare; the quantity recommended is one cubic centimetre, or about sixteen minims.

Asthma.—Inhalation of ether is very valuable to obtain relief in spasmodic asthma, and obtain sleep for the patient. It can be employed alone, or associated with tinctura digitalis or conium. The ordinary dose of the ether if from ten to forty minims, and the tincture of digitalis from ten to thirty minims.

The Ether-spray in Post-partum Hemorrhage.—Mr. W. Handsel Griffiths, of Dublin, reports in the *Practitioner* the use of the ether-spray in two cases of post-partum hemorrhage, in which the usual means of arresting the flow had been resorted to without effect. He directed the spray over the abdominal walls, along the spine, and over the genitals; in both cases the uterus contracted immediately, and hemorrhage ceased.

Coryza and Obstinate Hoarseness.—Drs. Chapman and Physick recommended the vapor of equal parts of Hoffman's anodyne or compound spirits of sulphuric ether with equal parts of laudanum in cases of recent catarrh, in coryza, and obstinate hoarseness, by inhalation.*

Chorea.—A jet or hand spray of sulphuric ether, free from alcohol, applied to the spine will relieve the most violent spasmodic or convulsive attack of chorea, with the subsequent use of Fowler's solution, five to ten drops three times a day in water, and occasional application of the galvanic current to the spine.

* I have also employed one-quarter grain of sulphate of morphia in the place of the laudanum, making a more elegant preparation, and with good success.

Nervous Aphonia, or Temporary Loss of Voice.—The vapor of ether has been highly recommended as a most valuable remedy in hysterical or nervous loss of voice. It has been the means of discovering malingerers, who were supposed or stated to be deaf and dumb,* and who, as soon as they came under its anæsthetic influence, were able both to hear and speak.

Diphtheritic Angina, or Pseudo-Membranous Croup.—Cases of diphtheritic angina have been treated with success by inhalations of ether and steam.

Whooping-Cough.—Ether alone by inhalation is extremely useful in the relief of whooping-cough; and a combination of ether sixty parts, chloroform thirty parts, and turpentine one part, has been found a most successful remedy, by confining the patient to his room, and making him, at every access of coughing, place before his mouth a small piece of cloth, folded several times, and wet with a teaspoonful of the mixture.† This remedy I have used with most gratifying results, at the same time employing, between the paroxysms, extract belladonna and quinine sulph. internally, with the inhalation of diluted carbolic acid in the patient's room.

ETHER IN MITIGATION OF THE AGONIES OF DEATH.

I avail myself of the reported trials of the late John C. Warren, M. D.,‡ "On the use of ether in mitigating the agonies of death," and his reasons for employing it in a free and decided manner. He says:—

"I am fully aware that the agony in the dissolution of the bond between the bodily frame and its spiritual tenant is not so great as it is believed to be; for, having questioned a great number of persons passing through the last stage of earthly existence, whether they suffered pain, the answer has been almost uniformly in the negative; and on inquiring what sensation was experienced, the reply has been such as

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* See Turnbull's Manual of Diseases of the Ear, pp. 312–315. Philadelphia: J. B. Lippincott & Co.

† American Practitioner, July, 1875.

‡ Etherization, with Surgical Remarks by John C. Warren, M. D., Emeritus Professor of Anatomy and Surgery University of Cambridge, Surgeon at Massachusetts General Hospital, Boston. William D. Ticknor & Co., Boston, 1847, pp. 70.

to lead me to consider it an undefinable sense of discomfort. The intellectual faculties appear to be so clouded and confused, that they are unable to take cognizance of the agitation which convulses the physical organization.

"There are, however, exceptional cases, in which there is great bodily suffering; and there is in all men an instinctive dread of the pains of death. If we find the means of preventing or relieving these pains, the great change may be viewed without horror, and even with tranquillity. He who would experience a real euthanasia should not, however, trust merely to the virtues of ether, but should also have settled his accounts with this world, and be well prepared to settle those of the future.

"In illustration of the practice alluded to may be mentioned the case of a lady, who died of dysentery in the summer of 1847, at the age of ninety. She had been my patient more than forty years; and during that time, besides heavy domestic calamities, had undergone a number of attacks of pleurisy, one of pericarditis, a severe and protracted bleeding from the stomach, with symptoms of malignant disease of this organ. She was once dangerously poisoned by eating partridge; moreover, by a fall she had a fracture of the neck of the thigh-bone, and soon after her restoration was attacked with senile mortification of the foot, from which, having suffered months of intense pain, she wholly recovered.

"Very temperate in her eating and drinking, and of a religious character, she was cheerful notwithstanding all these visitations; appeared to enjoy life more as she grew older, went out freely, and made two or three excursions into the country within a few weeks of her last illness.

"The dysenteric attack, which terminated her career, accompanied with symptoms of unusual severity, was only relieved for a very short time by the use of opium. After more than two weeks of illness, violent pain occurred in one of the feet, with discoloration, ending in gangrene. The pain of mortification suddenly ceasing under the use of opium, that of the abdomen returned, with convulsive twitchings of the limbs; and other remedies failing to mitigate these symptoms, inhalation of ether was employed with perfect relief.

"From the first inhalation to the period of her death five days elapsed, during which a considerable number of etherizations were used, and with such effect that, as soon as any suffering occurred, she desired ether. In the intervals, her mind was clear; she arranged such worldly matters as remained unsettled, received the consolations of religion, and finally, under ethereal influence, her spirit imperceptibly took its flight.

"VIVISECTIONS.—An excellent use of ether may be made in regard to animal vivisections. The people of this country, in common with their English progenitors, have always viewed the torturing of living animals for scientific purposes with invincible repugnance. Great has been the sacrifice of improvement in physiology and surgery which this sentiment has cost the medical profession. Ether enables us to lull the sensibilities of the victim, tranquilly pursue the natural workings of the internal organs, and the changes which take place from experimental applications; while the student of surgery can accustom himself to those gushes of the vital fluid, which, in the human body, are viewed with so much terror by the unpractised. Animals of any size may be etherized in a box, or by covering the head with an india-rubber sack, into which a mixture of ether and atmospheric air is forced."

VIVISECTIONS WITH ETHER AND CHLOROFORM.—Prof. Schiff, of Florence, states: "In our experiments, that is, in more than three thousand cases, we have adopted etherization with a view to preserve the life of animals; and that, with few exceptions, indicated elsewhere (Memoir on the Laryngeal Nerve), not a single case of death occurred. On the other hand, chloroform has cost us a considerable number of animals when I have wished to push anæsthesia to its ultimate stage."

CHAPTER III.

Ethers which have anæsthetic properties. Acetic Ether. Experiments by Dr. H. C. Wood on animals, etc. Formic Ether. Byasson's conclusions in regard to it. Hydriodic Ether. Properties and objections to its use. Methylic Ether. Dr. Richardson's experiments with it. Bichloride of Methylene. Observations upon it by Dr. Jones of Cork, Dr. Taylor and Spencer Wells of London. Iodide of Methyl. Amylene. Bromide of Ethyl, or Hydrobromic Ether. Properties. Mode of preparation, and experiments by the writer. Chloride and Bichloride of Ethylene. Oxygen, Nitrogen and Hydrogen Gases as anæsthetics.

ACETIC ETHER ($C_2H_5C_2H_3O_2$).

Acetic ether is colorless, and has an agreeable odor and burning taste. Specific gravity 0.89; boiling point 165°.2 F. If kept in contact with air, and in the presence of water, free acetic acid is formed. According to Dr. H. C. Wood, in pigeons and rabbits it produces perfect unconsciousness without as much previous struggling as when sulphuric ether is used, and has the advantage over that compound of being less inflammable; on the other hand, its volatility is less. No experimenter has employed this ether on man to produce anæsthesia.

FORMIC ETHER ($C_2H_5CHO_2$).

Formic ether is a colorless liquid, recalling the odor of rum, and having an agreeable taste. Specific gravity 0.915; density 62.8; boiling point 127°.3 F. It dissolves in nine parts of water and all proportions in alcohol, ether, fixed and volatile oils. Byasson made some experiments with it on animals, and found that this ether decomposed into alcohol and alkaline formiates through the alkalies of the blood. When inhaled, it lowers the temperature and induces asphyxia.

HYDRIODIC ETHER (C_2H_5I).

Hydriodic ether is a colorless non-inflammable liquid, having a peculiar ethereal odor and taste, soluble in alcohol,

and nearly insoluble in water. It boils at 158°.5 F.; specific gravity of liquid at 32°, 1.9755. Exposed to the air and light it liberates iodine and becomes brown, which irritates the nostrils and causes lachrymation, and is sometimes employed by inhalation to bring the system under the influence of iodine in chronic bronchitis and phthisis.

METHYLIC ETHER $(CH_3)_2O$.

Methylic ether is a colorless and very inflammable gas, heavier than air, of an oppressive odor. It is soluble in water, wood spirit, alcohol, and ether. A saturated solution in ether, at 32° F., has been recommended by Dr. B. W. Richardson, who experimented upon himself, and found that there was no preliminary spasm excited in the larynx or elsewhere. The pulse arose to ninety-six, and the anaesthesia was perfect; yet he objected to it, because it rapidly volatilizes from its solution, and on account of its unpleasant odor. Dr. Carter states: "In Dr. Richardson's own hands, I have seen the various (new) ethers act perfectly well, producing complete unconsciousness and relaxation of muscle without either struggling or sickness, and without unpleasant symptoms of any kind; but I cannot judge how far such results may have been due to the qualities of the agents employed, how far due to specially skillful or careful administration, or how far to the state of the patients themselves."*

BICHLORIDE OF METHYLENE (CH_2Cl_2).

Bichloride of methylene was discovered in 1840, but was introduced by Dr. B. W. Richardson in 1867. For some years it has received the fullest trials at Moorfields Ophthalmic Hospital, London, where they now use, almost exclusively, sulphuric ether. Within the two years' trial of the bichloride of methylene in the hospital above referred to, two deaths occurred without any indication of danger from the state of the pulse or heart; in the last instance of death, it occurred from the exhibition of one drachm and a

* In specific gravity, boiling point, etc., we have followed Prof. Wm. Allen Miller's Elements of Chemistry, Part III, Organic Chemistry (London: Longman, Green, Reader & Dyer, fourth edition, 1869), or Prof. Maisch's National Dispensatory (Philadelphia: H. C. Lea, 1879).

half of methylene to a healthy sailor, aged twenty-seven years. It has been employed not only in short operations, but also in such operations as ovariotomy. "Of this agent, Dr. Jones,* of Cork, has had considerable experience, having used it constantly for all minor operations in hospital and private practice for over seven years. Hard drinkers or old tipplers bore this form of anæsthetic badly, and on some occasions he has been alarmed and compelled to desist from its administration; he also found it to be dangerous in old cases of chest affection. His mode of administration was in a conical gauze bag lined with flannel, and containing a small sponge."

Mode of preparation.—Bichloride of methylene is both difficult and expensive to make. It is prepared by heating one part of methylic alcohol, two parts of common salt, and three parts of sulphuric acid, and passing the gas through water into a glass globe, into which chlorine gas is conducted at the same time. The globe is drawn out below so as to form a thin tube, which passes into one tubulure of a Woulfe bottle, the second tubulure being connected by means of a bent glass tube with a second Woulfe bottle, this second bottle being placed in ice; the other tubulure of this second bottle is connected with a flask cooled by means of a freezing mixture. The liquid which is condensed in the Woulfe bottles is chiefly chloroform, while that in the flask is almost pure methylene dichloride, or bichloride of methylene.

Bichloride of methylene is a colorless fluid, having an odor much like that of chloroform. It is pleasant to inhale as a vapor, and produces very little irritation of the fauces and air-passages. Its specific gravity is 1.344, and its boiling point 105° F. From its easier evaporation, it requires freer administration than chloroform; and because of its denser vapor, less quantity than ether.

I had a small quantity of it prepared by Dr. W. H. Greene, a competent chemist; and even with all his care the specimen contained chloroform. Its boiling point was 105° F. Bichloride of methylene has no action on test-paper, is

* Medical Responsibility in the Choice of Anæsthetics. By H. M. Jones, M. D., Surgeon to Cork Ophthalmic Hospital. Cork, 1876.

soluble in alcohol and ether, and is frequently mixed with other ethers in England, this being easily accounted for by the difficulty in making it, and its cost. These various mixtures give us a clue to its unequal character in regard to safety, in the hands of different experimenters. Its vapor has a density of 3.012, and burns with a bright flame. It has been tested by the late Dr. Washington Atlee, who did not find it as satisfactory as his mixture of ether and chloroform. Six deaths have occurred from its use. There is no doubt that it has many of the dangerous qualities of chloroform, as it belongs to the same chemical family, and death results from syncope, with dilated pupils.

The bichloride of methylene is employed in the Samaritan Free Hospital, of London; and the officer in charge of the anæsthetic states it to be very satisfactory. Junker's form of apparatus is used for its administration. The mortality from this agent is two in ten thousand, or one to five thousand. . . . .

As I have stated above, the strongest advocate for the bichloride of methylene or chloromethyl is Mr. J. Spencer Wells,* who believes that with this agent he has had all the advantages of complete anæsthesia, with fewer drawbacks than any other; this is his experience of five years, and of three hundred and fifty serious operations. He gives it diluted with air by Junker's apparatus, and, from his doubts of its composition, we suspect what he employs to be a mixture of methylic alcohol and chloroform. These are his own words: "Whatever may be its chemical composition, whether it is chloroform mixed with some spirit or ether, or whether it is really bichloride of methylene, I am still content with the effects of the liquid sold under that name."

Dr. Taylor† also states that "a mixture of chloroform and ether has been sold as bichloride of methylene. On shaking this mixture with water, the chloroform is separated and sinks." He reports three deaths from this agent, and the allegation, therefore, that the vapor possesses any greater degree of safety than chloroform in surgical practice, is not supported by facts.

* Meeting of British Medical Association, 1877.

† On Poisons, op. cit. p. 629.

DEATH FROM THE BICHLORIDE OF METHYLENE.

CASE 1.—A death from bichloride of methylene took place at the Ipswich Hospital, England, which affords a remarkable illustration of the relative safety of that drug and of ether. The patient was fifty-six years of age, and was to have had a necrosed bone removed from his leg. He was first given the methylene, which was changed for ether, for some cause which is not stated, but which may have been some alarming symptom produced by the methylene. Having taken the ether with safety until anæsthesia was obtained, the operation was proceeded with; but, the patient being allowed to wake too soon, the methylene was again resorted to; in fifteen seconds he was dead. No *post mortem* examination was made, but some ingenious person hazarded a guess that there had been unobserved apoplexy; and the jury, happy at any alternative except condemnation, adopted the hint, and voted the death accidental, and the medical officers free of all blame. A most unsatisfactory case in all its aspects, and one which should please the medical officers inculpated less than any one else; such a fatality may be hidden away by such a verdict, but no one can be satisfied, without evidence, that the case was not one of anæsthetic manslaughter. —*Medical Press*, *London*.

CASE 2. *Pharmaceutical Journal*, 1871, p. 875. Male, æt. forty. Given during an operation on the eye; result, death in five minutes. *Post mortem*, congestion of the lungs.

CASE 3. *Pharmaceutical Journal*, 1871, p. 875. Male. Inhaled ʒiss; result, death rapid. *Post mortem*, no special post mortem appearances.

CASE 4. *Lancet*, October 23d, 1869, p. 582. Mr. Marshall. Male, æt. thirty-nine; ʒiss. The man was sitting in a chair during the time of administration, and preparing for an operation. Symptoms, pupils slightly dilated; no stertor or lividity of countenance; result, death.

CASE 5. One of the most painful cases of death from the vapor of methylated ether occurred in the Birmingham Hospital, England, under Mr. Tait. A patient was about to undergo the operation of ovariotomy; five drachms of methylated ether in vapor were administered to her on a fold of a towel, by the resident medical officer. The pulse suddenly stopped, the pupils became dilated, and respiration

ceased; all efforts at restoration were fruitless. On inspection, the heart and all the other organs were healthy, except the ovary.—*Lancet*, July 5th, 1873, p. 23.

IODIDE OF METHYL (CH_3I).

This compound was discovered by Dumas and Peligot in 1835, and is made by combining phosphorus, iodine, and methylic alcohol. A safer and more agreeable preparation of it is made, according to Wanklyn, by mixing iodide of potassium and anhydrous methylic alcohol in a retort, in equivalent proportions; dry chlorine gas is passed into the mixture, which is then distilled, and the distillate agitated with water and rectified.

Iodide of methyl is a colorless liquid of an ethereal odor. Specific gravity, 2.199, at 32° F.; it boils at 110° F., and burns with difficulty, giving off violet vapors. This agent was proposed in 1868 by Dr. B. W. Richardson as an anæsthetic, but was found by him and by Prof. Simpson as unsafe. It has been recommended as a local anæsthetic in cancerous cases.

AMYLENE.

The vapor of this liquid was introduced by the late Dr. Snow as a substitute for the vapor of chloroform. It produces a loss of sensibility without causing complete coma or stupor. Its use has already led to at least two deaths, and is, according to Dr. Taylor,* not so safe an agent as chloroform vapor for surgical purposes. The only appearance met with in one fatal case was an emphysematous state of the lungs, or excessive dilatation of the air-cells (*Medical Times and Gazette*, April 4th and 18th, 1857, pp. 332, 381), and in the other a distension of the right cavities of the heart with dark fluid blood. There was no congestion of the brain, and no smell of amylene perceptible in the body.—*Medical Times and Gazette*, August 8th, 1857, p. 133.

BROMIDE OF ETHYL OR HYDROBROMIC ETHER (C_2H_5Br).

Bromide of ethyl (C_2H_5Br), or "hydrobromic ether," is a colorless liquid, with an agreeable odor; it boils at about

* On Poisons, op. cit. p. 627.

40°.7 C. (105°.8 F.), has a density of 1.419 at 15° C. (59° F.); the boiling point and density are, therefore, intermediate between those of chloroform and sulphuric ether.

Properties.—Transparent and colorless liquid, heavier than water (Serullas); specific gravity 1.40 (Löwig), 1.4733 at 0° (Pierre); vapor density 3.754 (R. Marchand J. per cm. 188); very volatile; boiling point 40°.7 C. when the barometer stands at 757 mm. (Pierre); has a strong ethereal odor and pungent taste (Serullas). According to Löwig, its taste is strongly and disagreeably sweetish, with a somewhat burning after-taste. The vapor, when inhaled, exerts an anæsthetic action, like chloroform (Robin, *Compt. Rend.* xxxii. 669). It is sparingly soluble in water, but mixes in all proportions with *alcohol* and *ether*.

Decompositions.—1. Vapor of hydrobromic ether passed through a glass tube at a low red heat is resolved into ethylene and hydrobromic acid gas. 2. It burns with difficulty, but with a beautiful green flame, which does not smoke, a strong odor of hydrobromic acid being at the same time evolved. 3. It is not decomposed by nitric acid, oil of vitriol, or potassium. 4. With ammonia it yields hydrobromate of ethylamine.

Bromide of ethyl absorbed by the respiratory passages produces, according to M. Rabuteau,* of Paris, absolute anæsthesia as rapidly, or even more rapidly, than chloroform. This result has been established with frogs, rabbits, dogs, etc. After five minutes' (sometimes after two minutes') inhalation, by means of a sponge saturated in bromide of ethyl, dogs were completely anæsthetized; the animals recovered more rapidly than when chloroform was used.

Bromide of ethyl is not caustic, nor even irritant, when compared to chloroform; it can be ingested without difficulty, and applied without danger, not only subcutaneously, but to the external auditory meatus and to the mucous membranes. In this respect it is preferable to chloroform, which is very caustic, and to sulphuric ether, of which the ingestion is nearly impossible. Introduced into the human stomach in doses of from fifteen to twenty drops, bromide of ethyl does not produce anæsthesia as when absorbed in sufficient

* Comptes Rendus, vol. lxxxiii. p. 1294; Pharm. Journ. and Trans.

quantity by the respiratory passages; it soothes pain, tends to induce sleep, and does not disturb the appetite.

This hydrobromic ether is sparingly soluble in water, and water shaken with it acquires a pleasant taste and odor; frogs placed in water so saturated undergo anæsthesia in ten or fifteen minutes. It is eliminated nearly entirely, if not completely, by the respiratory passages, whatever may have been the mode of absorption; at most, only traces of it are found in the urine when it has been introduced into the stomach, and an extremely small quantity can be detected in that secretion when it has been inhaled. Bromide of ethyl does not decompose in the organism to form an alkaline bromide. Bromide of ethyl is an anæsthetic agent, possessing properties intermediate between those of chloroform, bromoform, and ether.

I was the first to experiment with this ether upon man. It was prepared for me by Prof. J. P. Remington of this city, and subsequently in larger quantity by Dr. W. H. Greene. This ether was discovered by Serullas in 1827. It is produced by action of bromine on alcohol in the presence of phosphorus.

The method which Mr. Remington first employed was that of the celebrated chemist De Vrij, by distilling four parts pulverized bromide of potassium, with five parts of a mixture, of two parts strong sulphuric acid and one part alcohol of ninety-six per cent. The Professor then made the second sample of hydrobromic ether by a modification of Personne's process, replacing the phosphorus by amorphous phosphorus; but we found that the preparation had a phosphoric taste and odor, and contained minute particles of amorphous phosphorus. This amount of phosphorus produced brain disturbance, and a peculiar odor of mustard noticeable in the breath of those who inhaled it.

My first experiment was with a small quantity, and subsequently I used twenty-two ounces. I found it was colorless, with an agreeable odor and pleasant taste; the boiling point 40°.9 C., and its density heavier than water. When inhaled, it produced more of the agreeable effects of chloroform, and did not increase the pulse over its normal beat, whilst its action was very rapid. In the second state (because the ether first prepared was not pure, *i. e.*, free from traces of phosphorus) it caused an intermission of the pulse every

second beat. Three teaspoonfuls were added to a pint of water, and they sank to the bottom in globules; and upon being shaken, they were in part diffused without producing any change in the color of the water. A large-sized lively frog was then placed in this pint of water thus charged, and he made numerous endeavors to get out of it, and it required twenty minutes before he was fully under its influence. The anæsthetic effect was most profound; even his heart could just be felt making a most feeble effort, and his respirations entirely ceased, as far as I could judge; he was perfectly relaxed; the extremities became a livid-red color, and apparently lifeless, and no pinching or pricking was felt by him. After the frog had been removed, he remained in this state for fifty-eight minutes, and then began to make some slight movements; and, when the hour was up, was able to move about in a languid manner.

I made the following experiment with it in the ear:—A teaspoonful was mixed with one of glycerine and water, and was placed in the ear of a patient who was suffering from otalgia. The patient stated it gave her some pain, with a feeling of heat; but these sensations soon passed away, and her pain was relieved. No inflammation or caustic effects resulted from its use in the auditory canal, which was very irritable. I attempted to use a small quantity of chloroform on cotton in the same ear, but it could not be borne in contact even for a few seconds, it caused so much distress and irritation of the parts. A third use of it was by inhalation, on a patient about to undergo a painful operation; it induced a slight feeling of nausea, and she was very rapidly brought under its influence, and it did not produce the intermission in the pulse as in the first case.

I administer hydrobromic ether by the mouth, triturated with glycerine, gum-arabic in powder, or a small portion of spermaceti, as it is so much heavier than water, and its effect upon the mucous membrane is slightly irritating if not given properly (mixed), as it produces a feeling of warmth, and, as usual, eructation of gaseous ether.

℞. Ether Hydrobromic, xx♏.
Glycerinæ, f℥ss.
Acaciæ pulv. ʒii.
M.—Aqua font. f℥ss.

Sig. f℥i. ter diem.

It has the soothing effects of the bromides on the brain, and the same effects in relieving headache, ringing in the ears, or tinnitus aurium, *i. e.*, when there is no permanent organic change in the ear. It has all the properties of sulphuric ether in relieving colic, flatulence, and hysteria, also asthma and spasmodic cough. I have employed the hydrobromic ether by inhalation, and as intra-tympanal injected vapor in a number of cases in tinnitus aurium, where, in the most of the cases the noises were of a nervous character, *i. e.*, the result of functional disturbance, with success; but as the great majority of these cases of tinnitus arise and are kept up by an altered condition of the middle ear,* the result of excessive secretion of cerumen, blood, mucus, or pus, these latter conditions must be relieved by local and general treatment in conjunction with the hydrobromic ether, etc. I prefer the hydrobromic ether to nitrite of amyl or hydrobromic acid, there being less risk than with the first, and because of its having yielded better results than the acid in my hands. The following cases will serve to illustrate its advantage over chloroform as an anæsthetic, and for the relief of tinnitus before referred to.

CASE 1.—March 15th, 1878. Juniata W., aged eighteen, residence Pennsylvania; father living; mother died of congestion of the brain. General health good; both ears affected; ear most affected was the left; duration, three years; presumed cause, cold; lived near a damp mill; has also suffered from scarlet fever and measles; has no pain in the ears, but has a rustling and pumping noise in her head. The only treatment which she has had prior to visiting me, was washing out by syringing the ears. The meatus of both sides were free from even the normal secretion of cerumen; membrana tympani of both ears opaque, dull, sunken, and without any light spot; eustachian tubes narrowed; pharyngeal orifices swollen, and the swollen mucous membrane on edges disposed to close the faucial opening; nostril of the left side swollen and collapsed. Hearing distance of right ear, four feet with a watch of thirty feet; hearing distance of left ear, seven inches with the same watch. Stopping the ear pro-

* Tinnitus Aurium: Causes and Treatment. By L. Turnbull; 2d edition. J. B. Lippincott & Co., 1876.

duces dizziness; is subject to vertigo from slight causes; has chronic pharyngitis.

Diagnosis.—Chronic catarrh of middle ear and tubes, with congestion of labyrinth and semicircular canals, etc.

Treatment.—Careful use of eustachian catheter to inflate middle ear to remove the mucus; attention to throat by means of spray of carbolic acid, extract of pinus canadensis, etc. Used bromide of potassium for some time without much effect upon the noises, but with an improvement in the hearing of the defective ear to double the hearing distance by the 27th of March. The alkaline treatment was then changed to extract of belladonna, ergot, and hydrobromic acid, which was continued until May with less vertigo, but the noises continued. As her memory was more or less affected, the treatment was then changed to a solution of phosphoric acid as a lemonade; the eustachian tubes were touched at their orifices with a solution of nitrate of silver, of forty grains to the ounce of water, by means of the author's eustachian forceps, and then medicated and washed out through the nose by a solution of chloride of sodium. The hearing further improved to three feet, and the whole condition of the young person was improved; she had, however, still these noises. During May the spray of chloroform, nitrite of amyl, sulphuric ether, and hydrobromic ether, were all at different times passed into the middle ear by means of the eustachian catheter, and were inflated freely by means of Politzer's air-bag fitting to the orifice of the catheter. None of them even improved or relieved the noises except the hydrobromic ether; when fully under the influence of this agent the noises all disappeared, and after the effects had passed away she had not the distress in her head or heart which she had under the influence of chloroform, neither had she the disposition to faint which was produced by chloroform. Her recovery from the anæsthetic influence of the hydrobromic ether was prompt and complete, while it required fully one hour to recover from the chloroform, after which, for a whole day, she felt faint and distressed.

CASE 2.—April, 1878. T. L., aged fifty-seven, of Philadelphia, a gentleman of means, who has suffered from pericarditis, with irregular action of the heart, also with flatulent

dyspepsia and distressing pains in the lower bowels and rectum. He has had to resort to large doses of anodynes, with carminatives, for relief, and has had to be placed, at times, under the influence of sulphuric ether and chloroform; but the former agent always, from the first, caused great distress, clammy skin, and cough, owing to oppression following their use; with the latter, by distress in his head and heart, and intense throbbing of the vessels of the brain. I placed this patient three different times under the influence of hydrobromic ether, with entire relief to his pain and less distress of his heart, and more rapid elimination of the drug from his system.

CASE 3.—September, 1877. Jas. W. H., aged twenty-one, a mechanic, while making some alterations in my house, had been suffering with acute periostitis of the jaw, and, owing to exposure to cold, the inflammation became so intense and distressing that he had to give up his work. On examination it was found to involve the antrum highmorianum, and I feared pus had formed in it. I proposed at once to extract the tooth, and cut down to the bone; he was very timid and nervous, heart irregular and pulse fluttering, and desired to have an anæsthetic. Fearing the effects of chloroform, and the long period consumed in such cases by the administration of sulphuric ether, I proposed this new agent to him, and he agreed to it. I placed upon an Allis' inhaler f℥iij of hydrobromic ether, and, although he breathed it with great irregularity, in the course of three minutes he was fully under its influence. I extracted the tooth, and cut through the bone into the antrum, which incision was followed by a free discharge of blood and pus without his evincing the least indication of pain. His recovery was in about the same time as was consumed in the administration, and it was so complete that he was able to resume his occupation after an hour's rest. He had no vomiting, not even nausea following it.

CASE 4.—M. P., aged twenty-three years, student of medicine; health perfect, pulse sixty-eight, respiration normal, not at all nervous. On an empty stomach, inhaled, by an Allis inhaler, f℥iiss of hydrobromic ether, producing complete anæsthesia in two minutes and a half; pulse not influenced in the least, temperature normal, respiration but

slightly accelerated. So complete was the influence of the anæsthetic that the cornea could be touched with the finger without causing motion of the eyelids. Snoring loudly. From the time of discontinuing the administration to complete consciousness *just two minutes*, so that he was able to walk and talk coherently; had, after rising from the recumbent posture, slight vomiting of mucus.

Case 5.—With two drachms of hydrobromic ether completely anæsthetized a child of six years of age in about three minutes. While fully under its influence, slit up both canaliculi and introduced Bowman's probes, without evidence of pain; consciousness returned immediately after. The ether was withdrawn during the operation; no vomiting or other bad symptoms.

Case 6.—After the administration of about four drachms of hydrobromic ether, Allis' inhaler, secured sufficient anæsthesia to lacerate a soft cataract in a child three years of age. No other anæsthetic during the operation. No bad symptoms, no vomiting, and rapid return to consciousness.

Case 7.—Administered to a woman, by Allis' inhaler, hydrobromic ether. This patient was feeble, but heart normal; subject to bronchial asthma; stomach was fortunately empty. Complete anæsthesia was induced in three minutes, and kept up for five minutes, during removal of cystic tumor from her head; after operation there was slight vomiting of mucus.

Case 8.—A woman, aged twenty-five, with a peculiar hyper-sensitiveness of the whole alimentary tract, with excessive torpidity of the bowels, retroversion of the uterus, and neuralgia of the splanchnic nerves, with dreadful suffering. With a little less than one ounce of hydrobromic ether there was produced complete anæsthesia in four minutes, long enough for placing of a pessary to relieve the above symptoms. During the administration the pulse was but slightly accelerated; return of consciousness was accompanied by excessive gagging and vomiting of large quantities of mucus, great burning in stomach and throat, severe headache, cold perspiration, weak and rapid pulse, all of which continued for twenty-four hours, with more or less severity. Both sulphuric ether and chloroform had previously, on several occasions, produced similar symptoms,

but not so severely. Many of the distressing symptoms in this case were owing to the peculiar sluggishness of the intestines, due to the irritation caused by congestion and change of position of the uterus, and this extending to the ovaries, and passing up to the sensory nerves of that organ, thence to the nerve centres, whence it was reflected down to the splanchnics. At the time they are thus excited, and simultaneously with the arrest of the peristaltic action, the blood-pressure rises in the aorta and its branches, from the blood being driven out of the intestinal vessels by their contraction. In such cases large doses of opium would be the best remedy in pills of one grain, twice a day, with hot fomentations over the abdomen as a laxative.

CASE 9.—Child three years old, and perfectly healthy; had lacerated soft palate by running into it a pointed piece of wood. Two slight sprinklings of hydrobromic ether on a napkin sufficiently relaxed the patient, and produced such temporary anæsthesia as to permit touching of cornea and thorough examination and stitching of the wound, and full examination of fauces.

CASE 10.—March 21st, 1879. Dr. Wm. M. A., æt. twenty-three, was suffering the intense pain caused by a furunculous abscess in the anterior wall of the meatus auditoris. He had used leeches over the same region, and had lost a considerable amount of blood; hence his condition was not the best, as he was weakened by the loss of blood as well as by pain. Administered hydrobromic ether upon a towel.

"A small quantity of hydrobromic ether was placed on a towel, and by taking long inspirations, and expiring in the same manner, I was very soon under the effects; I could hold up the towel to my face no longer, and my hands dropped down to my side. Dr. Charles Turnbull then used the knife: I could feel it grate as he cut, but I experienced no pain. I do not think there was a total loss of consciousness, as I could see and hear what was going on around me. The hydrobromic ether did not have the nasty smell of the sulphuric ether. I had often taken this ether for purposes of experiment, and when I came out I most always had headache for some hours after. The after-effects of hydrobromic ether in my case, after the first five minutes, were nothing."

CASE 11.—O. E., aged twenty years; abscess of left lachry-

mal sac. Inhaled f℥ii on a towel; when under the influence of the hydrobromic ether hands fell to side as with Dr. A.; pulse 120 after operation, and before 100, and after first five inspirations 160. Stood up after operation (*i. e.*, opening and putting in a tent of linen), and said he felt the cut—the cold steel—but no pain; and after moving about, felt nothing from the ether. No sickness nor giddiness.

CASE 12.—Mary Adams, æt. twenty-five years, single, was suffering from the great deformity of symmetrical tumors of a large size on both ears, as may seen by figure 9. They had

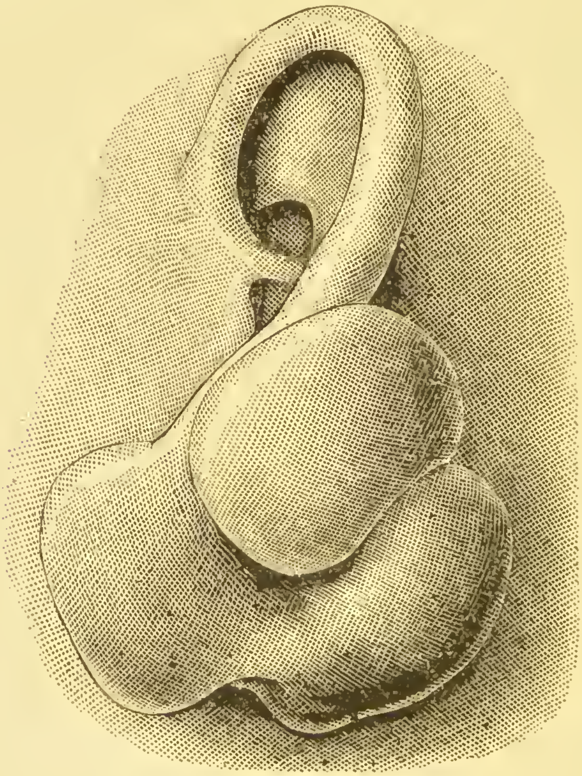

Fig. 9.

been removed six years previous, but had again returned of increased size. As the tumors involved the whole of the lobe and part of the helix and antitragus, it required tedious dissection to save all the skin and get rid of the fibrous tumor,*

* See page 135, A Clinical Manual of the Diseases of the Ear, by the writer, for a full account of the cause and pathology of these tumors.

which was almost as hard as cartilage, and avoid deformity. The patient was under the influence of sulphuric ether for one hour, and eight ounces were employed. With the second she passed more quickly under the influence of the hydrobromic ether, and the operation was completed in half an hour, stitching and everything, with the use of two ounces of the ether. The incisions both healed by first intention, and the patient has no appearance of the deformity, with both ears of smaller size but very natural appearance.

CASE 13.—March 25th, 1879. Same patient, Mary Adams. The operation was performed by Dr. L. Turnbull, assisted by Drs. Angney, Samuel R. Sterling, and C. S. Turnbull. The case was carefully watched, in order to test the influence of the hydrobromic ether on the pulse, respiration, general condition, etc., of the woman. Before the operation the pulse was 100 and the respiration 28, but this was somewhat excessive, and was doubtless caused by the patient running up and down two flights of stairs several times just before the hydrobromic ether was given; her normal pulse is 72, and respiration 20. Dr. C. S. Turnbull counted 160 for first minute, 160 for the fourth, 160 for the sixth, 160 for eighth; at the sixth minute the respiration was 30; from the fifth to tenth minute there was muscular rigidity. Pulse at twentieth minute, 84 beats in minute; twenty-two minutes, 90; twenty-five minutes, 100; thirty minutes, 96. Head and face were cold, and there was some perspiration after the ether was withdrawn. She said she felt no pain, although at times there was a state of muscular rigidity; the patient also stated that she did not feel so badly after this ether had been withdrawn as she did after she took the sulphuric ether, on the previous occasion, for removal of the same kind of tumor from the other ear. The hydrobromic ether was given while the woman was in a sitting posture, and she was able after its removal to take off her shoes and go to bed without any assistance; she was not able to do this after the other operation. The pupils did not seem to be influenced. This second operation took one-half the time of the first.

CASE 14.—Miss E. G., æt. seventeen. It was noticed, March 15th, 1879, that the walls of external meatus were slightly swollen, but there was no pain; and on 19th furunculous

5

abscess was diagnosed just within external meatus, which was so much swollen that even the smallest speculum could not be introduced, there also being considerable pain. Applied in the external ear a piece of cotton saturated with warm wine of opium, and directed same to be continued every few hours, with applications of cloths wrung out of hot water. During the time for the next three days she suffered very much, when she again presented herself at the clinic, and she was immediately given, by inhalation from a folded towel, f℥ij of hydrobromic ether, under the influence of which she passed without the least difficulty of respiration or any muscular resistance whatever; the time occupied did not exceed three minutes. The ether was now suspended and the abscess opened by Dr. L. Turnbull, the incision being made down to the bone; the part bled very freely. Hemorrhage was encouraged by injections of warm water, when the patient recovered consciousness, but with slight hysterical symptoms, which very soon passed off. After bleeding had ceased, a warm application of wine of opium was made, and the same treatment directed to be continued as prescribed on 19th inst.; she was given a prescription of quinia and strychnia sulph., guarded with a little hydrobromic acid. Patient returned to-day (22d) looking very much improved, and stated that yesterday she did not suffer from sick stomach nor headache, and was only affected with slight drowsiness during remainder of day, and slept well during the night, having no necessity to make use of the opiate prescription given her to take in case of insomnia. The meatus but slightly swollen, and by no means as painful as yesterday, but still precluding the introduction of the speculum.

CASE 15.—E. S., patient in Jefferson Medical College Hospital, superintendent of construction train on Pennsylvania railroad, has suffered with pain and inflammation in right ear since December, 1878, extending upwards over right side of cranium, and downwards over right mastoid region and neck. In December last was exposed to inclement weather, when soon thereafter the trouble appeared. Pain severest in afternoon; sleep greatly disturbed; tongue coated and bowels constipated. Previous health good; never before had a discharge from ears; no history of syphilis; speculum

examination reveals polypoid tumor, situated deep within and filling the right auditory canal, with a semi-purulent inodorous discharge; swelling and redness of mucous membrane, with exquisite pain upon pressure; hearing affected. March 26th, Dr. Laurence Turnbull decided upon removal of tumor, and, after consultation with Prof. S. D. Gross, the patient was anaesthetized by Dr. Drake with hydrobromic ether; and Dr. Turnbull introduced ear speculum, passing a wire-loop over the tumor, and twisted it from its base, followed with but little hemorrhage. About one ounce of the hydrobromic ether was used in producing complete insensibility, and the time consumed in doing so was about five or six minutes. During the administration of the anæsthetic, the pulse increased to eighty-four for the first two minutes, and ninety-six was reached during the last two minutes; breathing was not interrupted, nor was there any unpleasant effects after its use. Time consumed in removal of the tumor, about one minute or an additional half. Patient was ordered perfect quietness, with one-quarter grain of morphia under the skin and a blister over the swelling, with iron and quinine internally.

Conclusions.—From the fourteen cases first reported in my work before referred to, and the seven new cases, making twenty-one in all, I would deduce the following:—

	Minutes.	Seconds.
Shortest time taken to place a patient under the anaesthetic influence, .	0	30
Longest time, ...	5	00
Average time, ...	1	30
Average time under influence, . .		00

Smallest quantity of hydrobromic ether, two inhalations from sprinkled handkerchief.

Largest quantity of hydrobromic ether employed, two ounces.

Vomiting occurred in *three* cases after the administration; excitement (hysterical) in *two* cases; prostration in *one* case, but no alarm felt concerning the patient's life; no asphyxia nor fainting.

It will be noticed that, as yet, I have not resorted to its

use in a protracted operation. The advantage of this agent is the *rapidity of its elimination from the system* by the respiratory passages.

Action on the lower animals.—Rabbits and dogs are with difficulty brought under the influence of chloroform. Hydrobromic ether produces absolute anæsthesia with rabbits, dogs, and frogs, much more rapidly than chloroform does. With chloroform the shortest time required to place a small dog under anæsthetic influence was two minutes and thirty seconds; while with hydrobromic ether the shortest time with the same animal was but two minutes, and in from two to five minutes the animal had recovered all its powers. With a tin inhaler and a sponge saturated with bromide of ethyl dogs can be completely anæsthetized. With frogs, a sponge saturated with the same is placed under a bell-glass; water can be so charged with this variety of ether that a frog can absorb it through the skin; this requires a much longer time.

Action on man.—There is but very slight increase of the pulse or the arterial tension. There is a pricking feeling of the skin at the elbow and in the hands, with a rapid loss of power to move; the brain is comparatively free; pupils not affected; skin in some few instances cold and moist, but in the majority of cases natural. It differs from ordinary ether in the stage of excitement being short, the sedation and subsequent elimination rapid, in certain patients leaving a peculiar odor of mustard about the body of the patient; this I think was owing to a decomposition of the phosphorus.

BICHLORIDE OF ETHYLENE ($C_2H_4Ch_2$).

(DUTCH LIQUID.)

Bichloride of ethylene is a colorless, oily liquid, having an ethereal odor resembling that of chloroform and a sweetish taste; specific gravity 1.270, boils at 185° F.; sparingly soluble in water, and freely soluble in alcohol and ether; it is inflammable, and burns with a yellow flame with a green border. This agent, when tested by Prof. Simpson, was found so irritating to the throat that it could not be used long enough to induce the anæsthetic state. By the action of chlorine upon Dutch liquid a number of chlorinated

compounds may be obtained, which are isomeric with the chlorinated compounds.

ETHIDENE DICHLORIDE AS AN ANÆSTHETIC.

The following cases and remarks are given in the *Medical Times and Gazette*, January 18th, 1879, by Mr. Thomas Bird, M. R. C. S. E.:—

CASE 1.—Man, aged nineteen; a nervous patient. Pulse high at the commencement of the administration (98); in two minutes the pulse was 120, described as "full and bounding;" in the fourth minute it fell to 98, and the operation (tattooing opaque cornea) was commenced; in the eighth minute the pulse fell to 76—the anaesthetic was discontinued, the operation being finished; in the ninth and commencement of the tenth minutes the patient spoke, and answered the question as to where he lived. One drachm and a half of the ethedene dichloride had been used.

CASE 2.—A woman, aged fifty. In four minutes iridectomy was commenced, and finished in the fifth minute; in five minutes and a half the patient slightly moved her head in answer to question, and retched at the end of the fifth minute. The pulse 90 at the commencement; fell to 80, and never again exceeded 94.

CASE 3.—A child, aged three months. In this case, owing to the age of the patient, although I gave the anaesthetic in the same way, I gave it very slowly and cautiously. In three minutes iridectomy was performed; the child recovered perfectly in seven and a half minutes. Pulse not taken.

In the three following cases Mr. C. J. Parke, one of the four who had kindly assisted me, now took the apparatus, while I took the pulse and general observations myself; hitherto I had been quite satisfied with the breathing.

CASE 4.—A child, aged two years and nine months. Time of operation, four minutes and a quarter; half a drachm used.

CASE 5.—Boy, aged thirteen. One minute and a quarter, patient anaesthetized; pulse 108. Anaesthetic discontinued at the end of the fifth minute; a drachm and a half used. Pulse became fuller and more compressible at the end of the fourth minute. Sick afterwards.

CASE 6.—A man, aged twenty. This patient was under

the anæsthetic sixteen minutes; the operation was extirpation of eyeball. Pulse reached 110, with some slight excitement and conscious struggling, until and when completely anæsthetized, in the ninth minute, the face was flushed as after nitrite of amyl; the pulse fell to 72. The anæsthetic had been given as fast as possible, with the Junker apparatus; five drachms were used altogether; length of time of administration, sixteen minutes. Pupil was contracted till the end of administration, but responded to light.

Remarks.—Ethidene dichloride is hardly distinguishable from chloroform in appearance or odor, except that it may be a little sweeter and less pungent; of the latter there is no doubt, as the method of administration showed in comparison with chloroform and methylene bichloride. The intelligence seems confused almost immediately, the ordinary reflex phenomena remaining apparently a longer time than with either chloroform or methylene bichloride. When these patients were deeply anæsthetized, as in cases 1 and 6, the breathing was affected, becoming spasmodic and shallow (similar to that which I have noticed with animals under acetal, with which I have brought a mouse's respirations down to forty, followed by complete recovery); the pulse lowered, though much fuller in character and more compressible. All presented the appearance of a strong stimulant to the heart's action at the commencement of the administration; with regard to sickness, only one was actually sick. I think the anæsthetic is a good one for children, as being less rapid and pungent in its effect than usual.*

* The Scientific Grants Committee of the British Medical Association have received from a special committee a report (British Medical Journal, January 4th and 25th, 1879) upon the action of this anæsthetic, in which it is claimed that dichloride of ethidene presents all the advantages of ether, without any of its disadvantages; and that the following opinion of Steffen, given in Buiz's Evidence of Therapeutics, p. 39, is correct in most particulars: "It is said to have the following advantages over chloroform, which it resembles in its ultimate action, namely, a pleasanter smell, the power of producing narcosis more rapidly, as well as without excitement or vomiting, more rapid recovery without after-effects, and altogether less danger." In their experience, narcosis has not been produced more rapidly than with chloroform; but rapidity of narcosis depends very much on the mode of administration.

CHLORIDE OF ETHYLENE—ANÆSTHETIC FOR CHILDREN.

The *Hospital Gazette* gives a notice of Prof. Demme's article on this subject in the *Central Zeitung für Kinderheil-künde*, September 1, 1878. The chloride of ethylene (which chloride not stated), highly recommended as a safe anæsthetic by Dr. Liebreich, was used in twenty cases. While under its influence a child of eighteen months had a sudden and severe attack of asphyxia, which made it necessary to resort to the use of artificial respiration. (The Professor in this case may have used the chloride of ethyl, formerly known as muriatic ether, the effects of which are almost identical with sulphuric ether.)

OXYGEN, HYDROGEN, AND NITROGEN GASES AS ANÆSTHETICS.

In a notice of the author's work, it was stated that Dr. Gray, of Richmond, Va., had published in August, 1874, some observations regarding pure oxygen as an anæsthetic for short operations. I at once wrote to the Doctor, who sent me his paper, adding the following remark: "It is my purpose to continue my experiments with oxygen gas this winter, and I shall be happy to furnish you with a statement of results."

I have carefully read the article referred to, and found that the Doctor had made six experiments with the gas, the only test cases being in two patients. The first, a colored boy, took three gallons; pulse 80, respiration 24, temperature 98° F. In one minute and a half the pulse rose to 104, very feeble and intermitting; patient profoundly unconscious. Dr. Wood extracted one root, a superior molar; no complaint whatever was made, nor was there the slightest evidence or symptom of pain. The remaining two roots were now quickly taken out, with a scarcely audible groan on the part of the patient. In two and a half minutes he was fully reinstated, and said he did not know when the tooth was taken out; that his first sensation "was pleasant," the last "like that other gas," alluding to nitrous oxide, which he had taken on a former occasion. He remained seated in the

dental chair, and in ten minutes his pulse was 80, regular; respiration 16, temperature (interclavicular space) 101° F.

In the sixth experiment, Dr. Wood administered to Mrs. A. B. two gallons of the same gas, and while under its influence extracted eight anterior inferior teeth (temperature, pulse, or respiration not taken). The lady declared she "suffered no pain whatever."

These were the only minor surgical operations undertaken under the influence of the gas. In the other four cases the true effects of the gas were manifest, *i. e.*, slight exhilaration but no intoxication, lips and forehead purple, partial asphyxia, and in one case great cardiac excitement differing from that of nitrous oxide gas, with which the gentleman was very familiar, having frequently inhaled it.

I feel satisfied from these experiments, and those of Pflüger and others reported by Prof. Carpenter, that pure oxygen gas is not a true anæsthetic. He states:* "The respiration of pure oxygen for short periods, seven to seventeen minutes in man, produces no effect either in the rapidity of the pulse nor upon the temperature of the body, and scarcely any more of this gas is absorbed than under ordinary circumstances, which, as Pflüger has shown, is owing to the fact that arterial blood is charged, normally, with nine-tenths of the whole amount of oxygen it can take up. In small chambers the whole of the oxygen is used; but if the chamber be large, the amount of carbonic acid produced proves fatal before the complete consumption of the oxygen. Thus, Bert observed that when an animal was placed in an atmosphere of pure oxygen, with no provision for the removal of the carbonic acid eliminated, death took place when the proportion of this gas amounted to from twenty-six to thirty per cent., although the quantity of oxygen (seventy to eighty per cent.) was still found; when all the carbonic acid eliminated was removed, death occurred in mammals when the amount of oxygen had fallen to two per cent., and in birds when it was reduced to between three and four per cent. He further found that animals made to breathe oxygen at a pressure of five or six atmospheres, or which are exposed

* Effects of respiration of pure oxygen. Carpenter's Principles of Human Physiology, 1876, p. 103.

to ordinary air at a pressure of twenty atmospheres, fall into violent convulsions which last even after the pressure has been reduced to the normal. It would therefore appear that the oxygen, in entering the body at this high pressure, forms one or more compounds with some of its constituents, acting like strychnia."

Nitrogen and hydrogen may be considered as indifferent gases, proving fatal in a state of purity by permitting the accumulation of carbonic acid in the blood; as the carbonic acid replaces the oxygen, patients become livid, and to every external sign utterly insensible. All the true anæsthetics produce more or less asphyxia, but must have another property, that of producing exhilaration or intoxication.

Having read with pleasure the experiments of Dr. A. H. Smith, of New York, on oxygen gas, I addressed him the following note, which explains itself; also, his answer.

PHILADELPHIA, November 25th, 1878.

DR. ANDREW H. SMITH,

Dear Sir:—In the second edition of my little work on "Anæsthesia," I am desirous of giving some definite information in regard to oxygen gas; and having read with pleasure your experiments originally published in the *New York Medical Record* of January 2d, 1871, would be glad to be informed if you noticed any positive anæsthetic effects from its inhalation, as claimed by Dr. Gray, of Richmond, Va., and published by the *Virginia Medical Monthly* for August, 1874.

Yours, etc.,

L. TURNBULL.

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110 East Thirty-eighth Street,
NEW YORK, November 26th.

DR. L. TURNBULL,

Dear Sir:—I have your note of yesterday, and gladly respond to your inquiry.

In all my experiments with oxygen, and I often gave it very freely, I never observed any anæsthetic effect. I have not means of referring to Dr. Gray's article, but I suspect that in cases in which anæsthesia has been observed while oxygen was being inhaled, it was due to a number of very

deep inspirations succeeding each other rapidly, which we all know will produce a slight degree of anæsthesia even when common air is respired. I have often breathed pure oxygen for several minutes at a time, without experiencing anything more than a slight sensation of pressure or weight above the eyes; a few patients have complained of slight giddiness.

I transmit with this a copy of my pamphlet* on oxygen, which you may not have seen.

Yours, sincerely,

ANDREW H. SMITH.

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* Oxygen Gas as a Remedy in Disease; second edition. New York: D. Appleton & Co., pp. 56, 1870.

CHAPTER IV.

Chloroform, chemical composition, impurities, tests—Physiological action. Toxicological effects. Employment of Chloroform in labor. M. Pichard. Congress at Geneva. Drs. Lusk, Wilson, and Smith. Statistics of death from Chloroform. Table of one hundred and sixty deaths, with comments. Nitrite of Amyl as an antidote to Chloroform, observations and cases, by Drs. Richardson, Burrall, Lane, and Mundé. Mixed narcosis. Use of Morphia before inhalation of Chloroform. Therapeutical applications.

CHLOROFORM.

CHLOROFORM; dichlorinated chloride of methyl; terchloride of formyl. $CHCl^3$. Chloroform was discovered in 1831 almost simultaneously by Soubeiran in France, Liebig of Germany, and Guthrie of Sackett's Harbor, New York. Its true constitution was discovered by Dumas, in 1834.

The ordinary method of preparing chloroform is by the distillation of alcohol with chloride of lime. In its pure state it is a transparent and colorless liquid, having a specific gravity of 1.499; it has a pleasant and penetrating odor, and a sweet, fiery taste. It decomposes when exposed to air and light, with the formation of chlorine and hydrochloric acid, and becomes unfitted for inhalation; it should be kept in tin cases, in a dark place or under water. According to Prof. Maisch,* if pure chloroform is reduced to 1.484 with one per cent. of alcohol, it remains unaltered in diffused light for years, and for ten hours in direct sunlight, provided all moisture has been excluded. The products of the decomposition have the suffocating odor of *phosgene gas*, $COCl^2$. Partially decomposed chloroform may be restored to its original purity by agitating it with a solution of sodium carbonate, and rectifying it over lime. When chloroform is shaken with an equal bulk of sulphuric acid, no color should be imparted to either liquid, even after remaining in contact

* National Dispensatory, article Chloroform, p. 398.

for twenty-four hours; when it is agitated with an aqueous solution of nitrate of silver, a white precipitate of chloride of silver is not produced, providing the chloroform be pure.

Chloroform prepared from wood-spirit is specifically lighter, and has an empyreumatic odor from acids or chlorinated oils; and gives rise, when inhaled, to unpleasant sensations, with prostration and headache. Many chloroform accidents are doubtless due to impurities in the drug. A French chemist, M. Perrin, states that commercial chloroform, in France, has become much less reliable and more dangerous of late years; sleep is often difficult to get with it, and he mentions some cases in which the attempt had to be given up, after trying successively the drug procured in several shops; it often produces disorder of the stomach, moreover (vomiting, etc.), and twice in his recent experience it caused a state of apparent death, which was followed by extreme exhaustion.

Impure chloroform is recognized by the disagreeable odor it leaves after evaporation on a cloth which has been moistened with it, and by the yellow or brown color which it imparts to pure oil. A new test has lately been introduced for chloroform made from methylated spirit. It consists in mixing a solution of nitrate of silver (seventeen to one thousand) with ten times its volume of chloroform, and allowing it to stand for a few days, shaking it now and then; when, if methylated spirit (not up to standard of 128 to 130° C.) has been used, a deposit of a reddish-brown color will be found at the bottom of the vessel; with chemically pure chloroform there is no coloration. The smallest quantity of chloroform can be easily detected by adding to the liquid to be tested a monamine (or aniline) and an alcoholic solution of caustic potash; when it is present in large quantities, the peculiar odor of carbylamine is given off at once, or after gently heating when only traces are present. Pure chloroform placed upon oil of vitriol produces a contact-surface, convex downwards; impure chloroform gives a plane contact-surface. To detect the presence of alcohol a little chromic acid must be added to it, which will cause the chloroform to become green if alcohol be present; or, if a solution of molybdic acid in sulphuric acid be added, to become blue. Chloroform dissolves slightly in water, im-

parting its sweet taste to the liquid; it mixes in all proportions with alcohol.

PURIFIED CHLOROFORM—PHYSIOLOGICAL ACTION.

When one per cent. of chloroform is mixed with four or five per cent. of atmospheric air, it becomes charged with it, and in this form it is usually employed as an anæsthetic. It should be administered by means of a starched napkin, folded into a funnel shape, or by an inhaler,* held closely over the nostrils and mouth during inspiration, and in a reclining position. Its effects are divided into three stages. The first effect observed is a peculiar sensation of fullness, similar to the action of alcoholic stimulants, with a feeling of weight in the cerebrum; acceleration of the pulse, but no great increase in the heart's action; blunted sensibility and more or less tinnitus aurium. This first stage varies as a rule; it is generally short, but in intemperate persons it may be long and violent. In the second stage, which is that of complete anæsthesia, consciousness and sensibility are abolished, pulse slow and breathing regular; the entire muscular system is relaxed. These two stages sometimes run together. The third stage is one usually ushered in by stertorous, noisy, and "catchy" breathing, with weak irregular pulse, shallow and less frequent respiration, and dilated pupil, which is apt to be followed by collapse and death.

Death usually occurs by asphyxia, owing to the closure of the glottis, or to paralysis of the laryngeal muscles; or it may be induced by cardiac syncope, or absorption into the blood and nerve tissue, producing entire alteration of the nervous tissues.

What has experimentation determined definitely in regard to the action of chloroform?

The action of chloroform on the brain is, first, congestion; but when there is complete anæsthesia, it produces decided anæmia in man and animals (Carter). The muscular excitement of the second stage is, according to the experiments of Bert, purely physical; and there is, during the production

* See descriptions of various forms at the end of this volume.

of anæsthesia, a steady lowering of reflex action. Chloroform at first induces contraction, and afterwards dilatation of the pupil (Dogiel). During the first half minute of the inhalation of chloroform, there is a progressive lowering of the arterial pressure (English Chloroform Committee). Chloroform injected into the jugular vein instantly arrests the heart's action (Glover). Chloroform alone produces no other alteration than contraction of the red blood-disks (Boettcher); if, however, air be admitted to blood containing chloroform, the red corpuscles rapidly disappear, dissolving in the serum, out of which, after a time, hæmatin crystalizes. One authority (Husemann) states that, after anæsthesia, bile acids appear in the blood; and Bert has found that the oxygen of the blood undergoes an increase during anæsthesia. During the action of chloroform the temperature falls, the circulation is retarded, and the skin gives off less insensible perspiration (Sheinesson). According to the recent experiments of Ranke, which we have before referred to and repeated, on several small animals (and this is also the view of the late Claude Bernard), the nature of the action of chloroform upon the nerve cell is slight coagulation, but if the animal was killed with the chloroform there was hardening of the nerve trunks and entire change, in which evident coagulation of the albumenoid tissues took place; if chloroform was mixed with blood not exposed to the air, there was no change except contraction, either shown under the microscope or by spectrum analysis—this we* have repeatedly determined in the frog, rabbit, pigeon, and in the blood of several of the experimenters present, drawn and not exposed to the air.

TOXICOLOGICAL EFFECTS.

Chloroform is the most potent and dangerous of anæsthetics, and is the only one in which death may occur at any and every stage by inhalation; unlike ether, it kills so suddenly that neither skill nor care can guard against a fatal result. Prof. Silliman says: "The main disadvantage of chloroform is its high boiling point, requiring a great amount of vital force to eliminate it from the body, so that it is probably never eliminated entirely by the lungs, but only with the

* Drs. J. D. Thomas and L. Turnbull.

aid of all excreting organs, any deficiency or derangement of which may consequently lead to such suppression of elimination that the nervous system may be overwhelmed with consequent arrest of their activity." (Silliman's Lecture, 1871.) A recent writer* states that all anæsthetics kill during the first stage, or "the air may be very highly charged, even saturated, with either of these substances, so much so that, owing to its pungency, it cannot be breathed, and, if forced upon the patient, stifles and suffocates him in exactly the same manner as would brimstone or matches burned under his nostrils; death would thus occur without either chloroform or ether having entered the body." The writer gives no proof in favor of this theory, which is not based on facts, as in all anæsthetics death in the majority of cases occurs in the second or third stage (see tables), and it is very rare for it to occur in the first, except from chloroform mixture or from chloroform itself.

Owing to the danger which accompanies its use, chloroform should not be used when other anæsthetics are available; or under the especial circumstance that, without it, the shock of the operation might kill the patient. In military surgery, it becomes at times absolutely necessary; and in the hold of ships, especially those of iron, where the temperature is very high, it is resorted to on account of its rapidity of action, smallness of quantity required, cheapness, small bulk in transportation, and the less risk of explosion and ignition. In obstetrics, chloroform is used with comparative safety to the mother, although a few deaths have been reported; but from our observations taken in three carefully watched cases, all fatal to the infant, conclusions have been drawn that in long and instrumental labors ether, although not so pleasant, is much safer to the child.

The symptoms which usually occur as precursors of death are a sudden paleness or lividity of the countenance, with shallow breathing, stertor, loss of or a quick and weak pulse, tossing about of the patient, delirium, convulsions or coma.

Schiff (*l'Imparziale*) arrived at the following conclusions, after more than five thousand experiments, as to *the differ-*

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* Medical Times and Gazette, London, and Missouri Dental Journal, August 15th, 1878, p. 169.

ence of anæsthesia by ether or chloroform: "Ether paralyzes first the respiration, and after that the blood-vessels and the heart; while chloroform can paralyze the heart and blood-vessels at once, without previously paralyzing the respiration. Artificial respiration with the latter agent is, then, useless, as oxygenation has ceased; compression of the abdominal vessels, and lowering of the head, may be of advantage. Chloroform can cause death at the first inspiration. Ether is safer and less dangerous."

EXPERIMENTATION ON DEATH FROM CHLOROFORM.

"The first series of experiments I remember to have made were commenced in the years 1850 and 1851, and had reference to the mode and cause of death under chloroform. At the time named, chloroform had been in use a little over two years for preventing the pain of surgical operations, and already nineteen deaths in man had occurred from it.

"These calamities had produced very painful and anxious feelings amongst medical men, and my researches had for their intention the elucidation of many points of practical importance. The mode of procedure was to narcotize the animals, with various degrees of rapidity, with varying percentages of chloroform-vapor in the atmosphere, and during various atmospherical conditions; to note carefully the phenomena produced on the heart and on the respiration, and the duration of the four stages of narcotism. In some instances the animals—rabbits were usually subjected to experiment—were allowed to recover; in other instances the narcotism was continued to death. When the narcotism was made to be fatal, the immediate cause of death was noted, and the body left until the rigidity of death could be recorded; then all the organs were carefully inspected, in order to see what was the condition of the lungs, the heart, the brain, the spinal cord.

"The results obtained by these inquiries were of direct practical value; by them I showed, in various lectures and papers, the following major facts:—

"1. That the cause of the fatality from chloroform does not occur, as was at first supposed, from any particular mode of administration of the narcotic.

"2. That chloroform will kill, in some instances, when the subject killed by it exhibits, previous to administration, no trace of disease or other sign by which the danger of death can be foretold.

"3. That the condition of the air at the time of administration materially influences the action of the narcotic vapor; that the danger of administration is much less when the air is free from watery vapor, and the temperature is above 60° but below 70° F.

"4. That there are four distinct modes of death from chloroform, and that when the phenomena of death from its application appear, they are infinitely more likely to pass into irrevocable death than from some other narcotics that may be used in lieu of chloroform.

"5. That all the members of the group of narcotic vapors of the chlorine series, of which chloroform is the most prominent as a narcotic, are dangerous narcotics, and that chloroform ought to be replaced by some other agent equally practical in use and less fatal.

"6. That so long as it continues to be used there will always be a certain distinct mortality arising from chloroform, and that no human skill in applying it can divest it of its dangers.

"That knowledge of this kind respecting an agent which destroys one person out of every two thousand five hundred who inhale it, was calculated to be useful, no reasonable mind, I think, can doubt. To me, who, many hundred times in my life, have had the solemn responsibility of administering chloroform to my fellow-men, it was of so much value that I should have felt it a crime if I had gone blindly on using so potent an instrument without obtaining such knowledge."—Benjamin W. Richardson, in "*Nature.*"

MM. Budin and Coyne contribute to the *Archives de Physiologie*, No. 1, 1875, a communication on the condition of the pulse in anæsthesia. From their observations and researches they draw the following conclusions:—

1. The administration of chloroform causes a series of modifications in the pupil, which bear a relation to the state of sensibility.

2. During the period of excitation the pupil is dilated.

3. This period passed, the pupil becomes progressively contracted, remaining sensible to excitations.

4. During the period of profound surgical anæsthesia two phenomena on the part of the pupil are constantly observed: 1, an absolute immobility of this organ; 2, a state of contraction. There is a relation between the absolute insensibility of the subject and the contraction with immobility of the pupil; between the return of sensibility and the dilatation with mobility of this organ.

5. The state of the pupil may, then, from the point of view of sensibility, serve as a guide in the administration of chloroform.

6. Gradual dilatation of the pupil supervening during an operation indicates that anæsthesia is less profound, and that sensibility is returning.

7. During operations of long duration, if it is desired that the patient should be completely insensible, the anæsthesia should be so managed that the pupils should remain constantly contracted and immobile.

8. Efforts at vomiting may bring about dilatation of the pupil, cause insensibility to disappear, and bring about awakening; it annihilates in part the effects of the anæsthetic.

9. It is important not to confound true chloroform anæsthesia with asphyxic anæsthesia; the latter causes different phenomena on the part of the pupil.

10. The condition of the iris, although it may serve as a guide for the direction of anæsthesia, does not indicate the imminence of accidents. The pulse, the respiration, and the general condition of the patient, must be carefully watched by the administrator of chloroform.

Schiff* sought and found in the movement of the pupil an æsthesiometer to determine the sensibility, especially in curarized animals. With curarized dogs and cats every irritation of the sensory nerves in any part of the body resulted in a dilatation of the pupil, even when the irritation caused no pain, and excited only the tactile sensibilities, such as touching of the skin; the greater the sensibility, the greater the dilatation of the pupil. The dilatation manifested itself after the quickest and gentlest touch, which could not have changed the blood pressure; there was no other sign of feeling, hence the dilatation of the pupil is the best re-

* La pupilla come estesiometro. Imparzial. 1871.

action of sensibility. Schiff has thus attained important results in regard to the sensibilities of different organs and tissues that have hitherto been left in doubt. Irritation of any of the tissues, even muscles and tendons, will cause the pupil to dilate more or less. Of the spinal cord only the posterior columns are sensitive; an electric current applied to the gray matter of the cord, or to the anterior and lateral column, may cause a rise in the blood pressure, but it will not cause dilatation of the pupil.

There is some sensibility in the anterior four-fifths of the cerebrum, but none in the cerebellum. Electric currents in the intestines produced no dilatation, but mechanical irritation did. The dilatation of the pupil upon the irritation of the sensibilities is effected through the cervical sympathetic; it is suspended after its division, as well as the division of the medulla oblongata. In the brain is the change of the sensitive impression into the motor impulse. On the removal of the portion of the brain anterior of the corpora striata, the reflex action upon the pupil becomes slower; but on the entire removal of the brain the iris responds only to the impression of light, but not on irritation of sensibility.

The condition of the pupil during chloroform narcosis, according to Schiff, differs widely from Budin's observation. In the commencement of the narcosis, and until complete relaxation, Schiff found entire dilatation of the pupil, and that through the active contraction of the dilator or radiating fibres. Myosis does not continue in dogs (except sometimes in a very late stage of the experiment) long after a general muscular relaxation denotes great danger, or after death having ensued. Of eleven dogs which were chloroformed to the lowest blood pressure, or nearly to death, in four only was there a moderate contraction of the pupil, and never so strong as Budin states it to be. The dilatation which ensued, after sensible irritation, was only of short duration. Schiff concludes that the moment for operation, as indicated by Budin, is just the most unfavorable one, for all reaction upon sensible irritation is then extinct. There is a period in chloroform narcosis when all feeling of pain ceases, but consciousness is not entirely gone, when incisions or sawing of bones are perceived as mere tactile impressions, for the sensation of pain is conveyed to the brain through the gray

matter of the spinal cord; but the tactile impressions through the white matter of the posterior columns, which, being less vascular, do not so readily succumb to anæsthesia, and retain their function a little longer. Budin seems to have confounded impression from contact with sensation of pain.

Schiff refers to many observers who, like himself, have found the pupil of man and animals *dilated* during chloroform narcosis, but Budin has also many endorsers who saw the pupil *contracted* while in deep narcosis of chloroform. From these diametrically opposite results, we must conclude that chloroform does not act on all animals alike, and, further, that the different brands of chloroform are of unequal purity.

O. Liebreich, the distinguished chemist, maintains that when, on inhalation of chloroform, dilatation of the pupil ensues, that the chloroform is mixed with bodies of the bichloride series, which have the property of dilating the pupil, with final transition into the dangerous contraction stage.

Other anæsthetics which affect the pupil are mentioned by Schiff. It occurs in inhalation of nitrate of amyl that sensibility is retained, as manifested by the cries of animals, and yet the pupil does not dilate on irritation of sensibility, the very reverse in chloroform. Chloral exhibits the opposite effect of chloroform on the pupil, namely, a *very strong contraction*, a true myosis, without a preceding dilatation. The reflex dilatation upon irritation of sensibility ceases entirely, although other manifestations of pain continue for a while longer. Inhalations of chloroform which were made after an injection of chloral in a dog, brought about a slow dilatation of a strongly-contracted pupil.*

Speaking of deaths from chloroform at the very commencement of the inhalation, an able reviewer* has stated that "These sudden deaths are purely the result of emotion, a snapping of the vital cords strained to their utmost tension by the arrival of the long-dreaded moment for the operation.

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* Translated by Dr. S. Pollak, St. Louis, from Prof. A. Nagel's Yearly Review of the Progress of Ophthalmology. St. Louis Medical Journal, March, 1879.

† Anæsthetics, a Review in American Journal of Medical Sciences, January, 1867, p. 167, signed J. C. R.

Such sudden deaths during or just before an operation have always been known, and many reported."

I do not agree with the writer, else the same result would have followed when ether or nitrous oxide is employed. It is the same profound impression of this most dangerous of anæsthetics. Fright and apprehension will blanch the cheek, act upon the heart of feeble persons with cardiac troubles, but it cannot destroy so many strong, robust, and healthy subjects merely through moral fear. The reviewer has collected from different sources a number of interesting cases worthy of publication, but these will not prove the proposition, for the greatest number of deaths have occurred in the most trifling operations.

DEATH AT OUTSET OF ADMINISTRATION.

A death from chloroform occurred at the Toronto General Hospital on July 18th. A woman, aged twenty-five, was about to be operated upon for some uterine trouble, and but a few drops of the anesthetic had been given when she suddenly died. She had taken chloroform previously, and had had no unpleasant symptoms. At the *post mortem*, fatty degeneration of the right ventricle was assigned as the cause of death.*

A FEW ILLUSTRATIONS OF THE MODE OF DEATH FROM CHLOROFORM.

Deaths from Self Administration.—Dr. Gustav Judell, privat-docent and chemical assistant in Prof. Laube's clinic at Erlangen, was, on October 26th, found dead in his bed. He had been accustomed to take chloroform at night, as a remedy for sleeplessness, by which he was much troubled, and a bottle containing the anesthetic was found near him. It appears that vomiting was excited by the chloroform, but that he was too deeply narcotized to fully eject the contents of his stomach, so that portions of food remained in the trachea and caused death by suffocation.†

M. Bachelet, a young student of medicine, a son of the Professor of History at Rouen, having suffered from an in-

* Canadian Journal of Medical Sciences, August, 1877.
† Clinic, December 16th, 1876. From British Medical Journal.

tolerable toothache, endeavored to allay the pain by taking chloroform; but, having swallowed too large a quantity, he almost immediately fell to the ground as an inert mass. Notwithstanding every effort, he shortly after died.*

Deaths in the Dental Chair.—In the month of February, 1878, a Miss Wilson died in a dentist's chair in Brooklyn, after the extraction of ten teeth under the influence of two doses of chloroform. The coroner's jury, in summing up the evidence, gave as its opinion that the hapless woman died from asphyxia, caused by the use of chloroform, and they condemned the use of anæsthetics in dental operations. We do not wonder that dentists who are not always familiar with the number of fatal cases of death from the inhalation of chloroform employ it, when they see it recommended by some of the most distinguished surgeons of the land, in the face of the almost constant deaths from its direct influence; these latter are the culpable ones, for they sin against the knowledge of its fatal character. If no other anæsthetic could be found, there might be some reason for their willful misrepresentations. Where ether and nitrous oxide can be had almost perfectly safe, why should such a dangerous agent be recommended?

A case occurred at Rahway, N. J., on the 5th of January. A lad, aged fourteen, inhaled chloroform from a napkin prior to the extraction of a tooth; immediately after the extraction, there was a gasp for breath, a deep sigh, the head rolled on one side, and the boy was dead.

On Tuesday evening, March 22d, 1878, Mrs. William Neely, a resident of Hatboro, Montgomery county, Pennsylvania, came to this city, in company with her husband, for the purpose of having some teeth extracted. On Wednesday morning she went to the office of Dr. Winslow, on Tenth street above Race, and stated to him that she desired to have several teeth taken out and wished to take chloroform, but being in delicate health she was uncertain as to the advisability of doing so. The Doctor told her there was not any danger, and he administered the opiate, first for one minute, and then for a minute and a half, taking the usual precautions for the safety of his patient. After he had ad-

* Medical Times and Gazette, January 7th, 1877.

ministered the last dose, he found she did not return to consciousness, and despatched a messenger for Dr. E. B. Jackson, a few doors above, who pronounced the lady dead; Dr. Samuel W. Gross was also sent for, who made an examination of the lady, and expressed the opinion that she had died from heart disease.

The coroner's physician, Dr. Henry C. Chapman, testified that he had made a *post mortem* examination on the body of the deceased on March 20th, at No. 224 North Tenth street. On opening the chest found the lungs in a healthy condition, the heart soft and flabby, and a blood-clot adhering to the right side of the heart organs. In answer to questions from the coroner and jury, witness stated that before administering either chloroform or ether the physician or dentist administering it should on all occasions make a careful examination, and ascertain whether or not any heart-trouble existed. He thought that the deceased had been suffering from disease of the heart previous to having the chloroform administered by Dr. Winslow, as the clot adhering to the heart gave evidence of having been there for some time, and thought that she must have been unhealthy. From the flabby condition of the heart, the chloroform, in the opinion of witness, must have directly acted upon that organ. He thought that ether was less dangerous than chloroform; very few cases of death have resulted from the former, while hundreds of cases are recorded as having resulted fatally by the latter.

H. G. Winslow, M. D., residing at No. 224 North Tenth Street, on being sworn, testified that the deceased came to his office at noon on March 20th, for the purpose of having some teeth extracted; he asked her whether or not she was well, and she answered yes. He administered chloroform and extracted three teeth, she at the time being in a recumbent position; after extracting the three teeth, she came to and complained of feeling the pain. He administered more chloroform on a napkin, which he placed in close proximity to her nose, but not close enough to come in contact with the face, and she again sank into insensibility; in pulling an eye-tooth, after having administered the chloroform the second time, it broke off, and in attempting to remove the remaining portion he found that respiration had ceased with

his patient. He applied the usual remedies, consisting of electricity, throwing water in her face, and made every effort to secure an artificial respiration, but it was useless, as she ceased breathing; witness summoned Drs. Jackson and Gross, but when they arrived she had expired. Witness stated that he had used chloroform for a number of years, but never had anything serious to result from its use; he would not have administered it to Mrs. Neely if she had informed him that she was suffering from heart disease; the quantity of chloroform given to the deceased was about half an ounce. He has used both ether and nitrous oxide gas, and was of the opinion that there was as little danger in using chloroform as either of the former.

Mrs. Elizabeth Edgar, residing at 1836 Columbia Avenue, testified that she accompanied the deceased to the office of Dr. Winslow on the 20th of last month, and stated that he (Dr. Winslow) made no examination as to the condition of the deceased further than that he asked her whether or not she was healthy, and she responded in the affirmative; he administered the chloroform on two different occasions, a very short time intervening between administering it the first and second time.

The Verdict.—The testimony having all been received, the case was given to the jury, who retired for deliberation; after an absence of a short time, they returned and rendered the following verdict:—That the said Elizabeth Neely came to her death, March 20th, 1878, at No. 224 North Tenth street, by chloroform administered by Dr. H. G. Winslow; and they further find that Dr. Winslow is guilty of criminal ignorance, in administering so powerful a remedy, in not having made any examination of his patient.

The Dentist Censured by the Coroner.—After quiet had been restored, Coroner Gilbert, in addressing the accused, spoke as follows:—"Dr. Winslow, before discharging this case I must perform a duty which I owe to the community as their representative in this office, and that is to censure you for using so dangerous a remedy as chloroform in so trifling an operation as the extraction of teeth, more especially when you have at your own command a much safer substitute in sulphuric ether, and a perfectly harmless one in nitrous oxide gas. You are not only to be censured for using chlo-

roform in such a case, but using it without having previously made a careful examination into the physical condition of the various organs of your patient's system. Chloroform is a most powerful sedative, and far more dangerous to life than any of the other anæsthetics; on this account, a number of the hospitals have prohibited its use. The medical profession have almost unanimously settled down to the opinion that it should only be used in capital operations, and then only after the most careful examination. Although the verdict of the jury and this censure will not bring back the mother to the little ones, or the wife to her husband, it may be the means of directing the attention of dental surgeons to a more careful use of chloroform, and the community, who are the parties most interested, to the great danger attending its use, and thus, perhaps, avoid similar accidents in future. In concluding, Coroner Gilbert committed the accused to await the action of the grand jury."

I addressed a note to the coroner in regard to the action of the grand jury, and received the following reply:—

PHILADELPHIA, March 22d, 1879.

DEAR SIR:

The grand jury ignored the bill in the Winslow case.

Very respectfully,

W. K. GILBERT.

To L. TURNBULL, M. D.

DEATH IN SURGICAL OPERATION.—Dr. W. P. Mills, of Brownsville, Mo., reports the following death in the *St. Louis Medical and Surgical Journal* of June, 1878:—

"A few days ago I was requested to operate on a boy, aged sixteen years, for congenital phimosis. He was chloroformed by Dr. A. J. Parsons, who has often administered chloroform by inhalation; and, by the way, he is very cautious in the administration of this potent drug. Notwithstanding the great prudence, caution, and the general manner in which it was administered, just as the operation was completed, and without any indication of danger whatever, instantaneously—almost as quick as the explosion of gunpowder—respiration ceased, and a livid color overspread his face; and in spite of all the usual restoratives, he was soon dead—in fact, it seemed as if he was struck dead in an instant. Immediately upon the supervention of these

alarming symptoms, his head was lowered, cold water thrown into his face, and artificial respiration induced; under the influence of this treatment some improvement was manifested, and for a few seconds it seemed that the danger was over, but suddenly all the alarming symptoms before described were again exhibited, and death was the inevitable result. Not more than three drachms of chloroform was used, and of this not more than one and a half or two drachms were actually inhaled; and the patient was not deeply under its influence at any time during the operation, which, as a matter of course, was very brief. Nitrite of amyl, electricity, and hypodermic injections of whiskey were all brought into requisition, but, as the sequel proved, were of no avail.

"The most noteworthy feature of the case was the very sudden supervention of the alarming symptoms; for, according to my information in regard to chloroform poisoning, there is generally some warning given of its deleterious influence."

Quantity of Chloroform found in the Blood of Patients after Death.—MM. Perrin and Lallemand* found that—the blood being taken as the standard, representing 1—the brain contained 3.92 parts, the liver 2.08, and the muscles 0.16.

Period of Administration of Chloroform at which Death occurred (Sansom†):—

Before full effects,	50
During full effects,	52
Not stated,	7
	109

Sex—Men more subject to Death than Women:—

Snow gives the proportion of	3 to 2
Kidd " "	4 to 1

Sansom and the Chloroform Committee 2.8 to 1, and 72 males to 37 females.

Age—Largest proportion of Deaths during Middle Age.—Children have shown great immunity, and yet they also die from its effects.

* Traité d'Anesthésie Chirurgicale, Paris, 1863, 8vo.

† Chloroform: its Action and Administration. London, 1865.

KIND OF OPERATION IN WHICH DEATH OCCURRED BY THE ADMINISTRATION OF CHLOROFORM:—

Operations of minor importance, as extraction of teeth,	88
Capital operations, ...	9
Reduction of dislocations, ...	6
Delirium tremens and mania, ...	4
Natural labor, ...	2
	109

The quantity of chloroform necessary to produce death is very variable. As small a quantity as from seventy-five to one hundred drops has caused death, and yet, in a recent case which has come under our notice, as much as three pounds were employed in twelve hours, and no serious results followed to the mother in confinement, but the infant died from the profound narcosis.

Dr. Taylor, of London, in his work on Poisons,* states that "Fatal cases have been proportionally much more numerous from the use of chloroform-vapor than even from (the impure) ether-vapor employed in England." After relating a number of fatal cases, in which as small a quantity as a drachm of chloroform in vapor produced death suddenly, he remarks: "It is not necessary that this theory, that a fatty and flabby heart is the true cause of death, be brought forward to explain the fatal results—*they are simply cases of poisoning*." Then he relates that death of a hearty man took place on the operating table of a London hospital in three minutes, from two drachms of chloroform given in vapor; the gentleman who administered it had given it previously to three or four hundred patients. It was on this occasion candidly admitted that the body was quite healthy. This is the reason why so many eminent and conscientious surgeons have given up the use of chloroform, except in rare cases, for fear such a catastrophy might occur. A recent case of death from chloroform, in which a distinguished Southern surgeon† met with his first fatal case, followed, however, an operation on a diseased subject. This surgeon, during the war, is reported to have administered chloroform fifteen thousand times without one death.

* On Poisons, opt. cit. pp. 621, 622. † Prof. McGuire.

We also know, from private information furnished by one of the most careful and reliable surgeons of our city, of fatal cases of death from chloroform which have never seen the light of day; and we feel sure that there are other such cases which have occurred on the battle-field, at sea, and on the railroads, following severe shock, and that the patients died, not from the injury, but from the narcotic effects of this most powerful poison, administered before reaction had taken place. These statements are not made from mere hearsay, but were received in confidence from surgeons of high rank in the army and navy, and who were in active service during the late war.

What are the means to be resorted to, to prevent death from this agent, when it is found absolutely necessary to resort to its use?

What is, then, the chief danger to be apprehended, and how do we prevent closure of the glottis, fainting, and failure of the pulse?

Stop the administration of the chloroform.

Lower the head, and elevate the feet above the level of the body, and remove what mucus may collect in the mouth; *draw out the tongue* and elevate the jaw.

Administer five to ten drops of nitrite of amyl, dropped from a bottle on a piece of cloth and held to the nose. If the patient makes no effort at breathing, force it up the nostrils by means of a small hand-spray, compressing and expanding the chest by manipulation with elbows to the side. This should be continued until the heart acts.

If there is still increased evidence of asphyxia, owing to falling back of the tongue and closure of the glottis, seize the tongue with a dry napkin wrapped around it, or with a catch-forceps, and pull it forwards until its tip is well between the teeth, and hold it there.

Give the patient plenty of fresh air, by opening the windows, fanning, use flagellation, etc.

If these means fail, commence artificial respiration at once.

Apply a galvanic or Faradayic current along the course of the pneumogastric nerve, through the diaphragm, and even to the heart, by means of electrodes of metal, containing sponges which can be moistened with hot salt water.

Let the assistants or nurses rub each extremity briskly

with a hot towel; sprinkle the face, by the fingers, with ice water, and insert a lump of ice in the rectum, or inject whiskey or brandy into the reetum or into the skin hypodermieally.

As soon as the patient ean swallow, stimulate with brandy, whiskey, and aromatic spirits of ammonia; adding, if for a female, the ammoniated tincture of valerian.

After successful resuscitation, dry the skin; give the patient warm beef-tea and milk; apply warmth around the body for seven or eight hours by means of hot-water bottles, heated bricks, bags of hot salt, ete.

Prof. Silliman thinks the best treatment in impending death from chloroform is the introduction of air, heated to 130° F., into the lungs by artificial respiration, by means of bellows.

T. Hughes, M. D., in *London Lancet* of November 2d, says: "If I were about to be placed under the influence of chloroform, I would say, 'Never mind my pulse, never mind my heart; leave my pupil to itself. Keep your eye on my breathing; and if it becomes embarrassed to a grave extent, take an artery forceps and pull my tongue well out.' It was the observance of this simple yet all-important rule that enabled the late Mr. Syme to say that he never lost a single case from chloroform, although he gave it in five thousand cases. Prof. Lister has done much to enforee this rule of practice, and to him is due the credit of pointing out the *modus operandi* of this proceeding. He was the first, as far as I am aware, who explained that its action is not mechanical, but is exerted chiefly through the nervous system."

Prof. Schiff warns surgeons not to continue an operation immediately on a patient's recovery from the excessive action of anæsthetics, but to wait until respiration has been energetically restored, otherwise a new and generally fatal asphyxia may be produced.

It is well to remember that anemia of the brain is secondary to the cessation of the heart's aetion, and that to restore vitality to the brain requires that the heart's *action* be restored. For the purpose there is nothing better than electricity, and the use of it is to be eontinued, not only for a few moments, but for three or four hours. In cases of opium

narcosis, some have recovered after the use of the Faradayic current during fifteen consecutive hours, and it is well worthy of trial for as long a period in a case of chloroform poisoning.

APPEARANCES AFTER DEATH FROM CHLOROFORM.

In our table of deaths from chloroform the details, as far as known, are given, but the chief *post mortem* effects produced by death after chloroform are congestion of the brain and mucous membranes of the air-passages and alimentary canal; the bronchia are filled with mucus.

EMPLOYMENT OF CHLOROFORM IN LABOR.

M. Pichaud read a paper before the International Medical Congress of Geneva (*Gazette Medicale*, October 20, 1877), in which he advanced the following conclusions, which are not generally approved of by the majority of gynæcologists:

1. The employment of anæsthetics is, as a general rule, advisable in natural labor.

2. The principal substances which have been used for this purpose up to the present time: chloroform, amylene, laudanum, morphia hypodermically, chloral by the mouth and by injection.

3. Of these, chloroform seems to be preferable.

4. It should be administered according to the method of Snow, that is, in small doses at the beginning of each pain, its administration being suspended during the intervals.

5. It should never be pushed to complete insensibility, but the patient should be held in a state of semi-anæsthesia, so as to produce a diminution of the suffering.

6. The general rule is never to administer chloroform except during the period of expulsion; but in certain cases of nervousness and extreme agitation, it is advantageous not to wait for the complete dilatation of the os uteri.

7. Experience has shown that anæsthetics do not arrest the contractions of the uterus or abdominal muscles, but that they weaken the natural resistance of the perineal muscles.

8. The use of anæsthetics has no unpleasant effect on the mind of the mother or upon the child.

9. In lessening the suffering, anæsthetics render a great

service to those women who dread the pain; they diminish the chances of the nervous crises which are caused during labor by the excess of suffering; they make the recovery more rapid.

10. They are especially useful to calm the great agitation and cerebral excitement, which labor often produces in every nervous woman.

11. Their employment is indicated in natural cases until the pains are suspended or retarded by the suffering caused by maladies occurring previous to or during labor, and in those cases where irregular and partial contractions occasion internal and sometimes continuous pain without causing progress of the labor.

12. In a natural labor, chloroform should never be used without the consent of the woman and her family.

The experience of British practitioners is generally understood to have disposed them to regard the use of chloroform in labor as a proceeding of the highest utility and moment; and, according to the mode and limits of inhalation practised in the circumstances, practically free from danger. It is none the less important, therefore, to notice the opposite views entertained by others; and to speak of France, where chloroform in labor has not yet become acclimated, and where medical science generally has for the last quarter of a century fallen into the background. Dr. William T. Lusk, of New York, read before the American Gynæcological Society an interesting paper on the necessity of "Caution in the use of Chloroform during Labor," in which he expressed his belief that "not a small number of persons have quietly abandoned chloroform as a pain-stilling agent, because some incident in their practice has led them to suspect that, in spite of statistics, it possesses dangerous properties." The author divides his subject according to the following heads:

1. *Deep anæsthesia, carried to the point of complete abolition of consciousness, in some cases weakens uterine action, and sometimes suspends it altogether.*

2. *Chloroform, even given in the usual obstetrical fashion, namely, in small doses, during the pains only, and after the commencement of the second stage, may, in exceptional cases, so far weaken uterine action as to create the necessity for resorting to ergot or forceps.*

3. *Patients in labor do not enjoy any absolute immunity from the pernicious effects of chloroform.*

4. *Chloroform should not be given in the third stage of labor. The relative safety of chloroform ceases with the birth of the child.*

5. *The more remote influence of large doses of chloroform, during labor, upon the puerperal state, is a subject that calls for further investigation and inquiry.*

Dr. Playfair* thinks that chloroform inhalation is too indiscriminately used, and says that he has observed the pains alter and become less effectual. After chloroformization, and when it is prolonged, he thinks it favors post partum hœmorrhage.

In a recent case which came under the writer's notice, where three pints of chloroform had been employed in tedious labor, there was great retardation; and ultimately, when the forceps were applied, the infant was so narcotized from the effects of the chloroform that every means employed to restore it failed.

Dr. Colling reported in the *Boston Medical and Surgical Journal* of January 11th, 1876, a case of death by chloroform in parturition. The patient was a primipara, aged twenty-two. The labor was proceeding well, and the head was apparently on the point of emerging, when the patient had a slight convulsion. Chloroform was administered, and the pains returned; and, still later, the administration was repeated. The head was gotten away, and the uterus was contracting well, when a tremor occurred, the pulse ceased, and the patient was dead.

CHLOROFORM AS AN ANÆSTHETIC FOR CHILDREN.

Prof. Demme, in the *Central Zeitung für Kinderheilkünde* of September 1st, 1879, gives his experience in the use of chloroform as an anæsthetic for children, which corresponds in part with our own observations and experiments. He says: "Its action is quicker, more reliable, and in no way more dangerous." This last expression must, we think, be modified, for deaths have followed its administration in

* British Medical Journal, November 9th, 1878.

children in several instances, of which the following is a list*:—

Date.	Sex.	Age.	Operation.
1849,	Boy,	12,	Amputation.
1850,	—	1,	Naevus.
1857,	Boy,	9,	Tumor of scapula.
"	"	5,	Tumor of back.
1858,	"	8,	Strabismus.
"	"	11,	Injury of toe.
1859,	Girl,	$7\frac{1}{2}$,	Hip disease.
1861,	Boy,	7,	Laryngitis.
"	"	8,	Deformity from burn.
1865,	—	2,	Amputation of finger.
1866,	Boy,	$4\frac{1}{2}$,	Retention of urine.
"	"	11,	Lithotomy.
1867,	Girl,	9,	Strabismus.
"	Boy,	8,	"
1869,	Girl,	6,	"
1870,	Boy,	11,	Iridectomy.
1871,	"	8,	Dressing wound.
"	"	12,	Extracting teeth.

THE USE OF CHLOROFORM IN REGARD TO NATIONALITY AND RACE.

Dr. M. F. Coomes, of Louisville, Kentucky, writes in the *American Bi-weekly* of September 14th, 1878: "The Irish, as a class, will take more chloroform and be longer in yielding to its influence than any other nationality. The behavior of Americans is similar to that of the Irish; they possess great power of resistance, but yield to the influence of the anæsthetic with more ease and take less of it. The Germans yield to chloroform with but little trouble; it is not an infrequent occurrence to see them become anæsthetized without a struggle. They rarely make any demonstration; if they do, it is usually in the form of rapid conversation or song. The negro is more easily influenced by chloroform than either of the before mentioned races; they usually become anæsthetized very readily; in many instances they sing and pray while inhaling."

* Collected for me by Dr. O. H. Allis. See also table of deaths from chloroform.

These observations were taken in fifty-seven cases, of which the Doctor kept an accurate record.

TOLERANCE OF CHLOROFORM BY THE USE OF AMMONIACAL INHALATIONS.

Some patients are dangerously affected by chloroform inhalations; while, in others, tolerance is obtained with considerable difficulty. It may also happen that chloroform, although obviously indicated, could not be employed on account of severe cardiac complication.

Professor Occhim had a patient, requiring the removal of a large calculus, who was much enfeebled by a chronic suppuration, and whose pulse was irregular and thready. Under these discouraging circumstances, the Professor employed the preventative effects of ammoniacal inspirations as a stimulant to the nervous and vascular systems, and a very large calculus was extracted without difficulty or disturbance of these systems; the patient made a good recovery. M. Occhim made several experiments on patients laboring under cardiac difficulties in their various stages, and thus confirmed the conclusions at which he arrived at, *i. e.*, that the tolerance of chloroform can be ensured by the preventative use of ammoniacal inhalations.*

THE INFLUENCE OF CLIMATE ON THE USE OF CHLOROFORM.

The following extracts, in reference to the use of chloroform, were taken from letters received from two distinguished surgeons in the South. The first is from Dr. Landon B. Edwards, editor of the *Virginia Medical Monthly*, dated Richmond, Va., October 21st, 1878:—

MY DEAR DOCTOR:

. . . .

It is one of the most peculiar facts that I have ever known in medical practice—the difference of experience in Europe and the North with chloroform and ether, as compared with that at the South. I don't understand the high rate of mortality with chloroform elsewhere; or else, I cannot explain the low rate of mortality at the South from

* Medical Examiner, April 25th, 1878, and Medical News and Library, July, 1878.

the same agent. Anæsthetics are used for more trivial affections and surgical operations in the South than in the North; and, of course, for all grave troubles, many obstetrical cases, etc. Even during the war, when we Confederates were not using Squibb's, or a chloroform having the reputation of such purity, our preference was for chloroform, although of home manufacture, and I know of no army surgeon in the Confederate service who had any occasion to regret his preference for it; of course, some accidents may have occurred with it, but I do not recall any fatality directly or solely attributed to it. But it seems to me almost every practitioner of eminence in the North has knowledge of some fatality from chloroform. Were a fatal case from anæsthetics to occur in any of our small cities or towns, it would become wide-spread news.

Yours truly,

LANDON B. EDWARDS.

The second, dated October 26th, 1878, is from Dr. A. W. Calhoun, an eminent ophthalmic and aural surgeon of Atlanta, Ga., who administered chloroform even in the removing of tonsils, etc., without fear:—

MY DEAR DOCTOR:

. . . .

My recent experience has also taught me that it is perfectly safe, and oftentimes *very* desirable, to give chloroform, at least to the extent of enabling you to begin the operation without resistance on the part of the patient.

. . . .

I am, etc.,

A. W. CALHOUN.

There may be something in the difference in the boiling-point of chloroform in the South, and in the fact of the air being more heated and stimulating.

CONCLUSIONS IN REFERENCE TO THE USE OF CHLOROFORM.

In what class of cases can chloroform be employed with safety?

In my own experience and after my experiments, I would limit the use of this most potent of all the anæsthetics to *very young children*, or those who are weak, strumous, or

overgrown; to puerperal eclampsia, in very violent convulsions, in male adults, or in females during delivery, where rapidity of dilatation of the os uteri is absolutely necessary to save the mother's life.

In some rare cases of painful operation, where, after continued efforts, no complete insensibility can be produced by ether, I would feel justified in the use of a small portion of chloroform on a clean sponge or inhaler. By a reference to the recent cases of deaths from this agent, I am fully satisfied that no amount of care or precaution, or mode of administration, or amount inhaled, will prevent, in certain cases, the fatal result; and yet physicians and others will resort to the use of chloroform on account of its pleasant taste and odor, rapidity of action, cost, and comparative bulk.

In the recent admirable work on surgery by Erichsen,* he discussed the question, Do anæsthetics influence the rate of mortality after operation? and concludes by stating: "I am inclined to believe that the rate of mortality has increased since the use of anæsthetics in operative surgery." Again, "I cannot but think that chloroform does exercise a noxious influence on the constitution, and does lessen the prospect of recovery in certain states of the system, more especially when the blood is in an unhealthy state." He states the most dangerous condition in which to administer chloroform is that in which, in consequence of renal disease, the blood is loaded with urea; in such cases epileptiform convulsions are readily induced.

In the recent work of Professor Billroth,† of Vienna, he states: "Recently, ether has come more into use on account of the number of deaths from chloroform. I now use a composition of three parts chloroform, one sulphuric ether, and one absolute alcohol, which seems less dangerous than chloroform."

There have already been *two hundred and ten* deaths from chloroform faithfully recorded and reported (see first edition of this work, Philadelphia, 1878). Most of these occurred in the hands of the most experienced surgeons, and many of them in large hospitals where every appliance was to be had

* The Science and Art of Surgery, p. 42. Philadelphia: H. C. Lea, 1878.

† From the Fourth German Edition.

TABLE OF DEATHS FROM CHLOROFORM FROM 1869 TO 1879.

No.	Date.	Name or Sex.	Age.	Why Administered.	Time of Death.	Quantity.	Apparatus.	Administrator.	Conditions of Patient.	Symptoms.	Cause of Death.	Post Mortem, &c.
1	Jan. '69	Male	20		Before.		Towel	Prof. Billroth, Austria	Anæmic	Convulsive movements	Collapse in consequence of anæmia	Negative, viscera anæmic. Patient died fifteen minutes after commencement of alarming symptoms.
2	"	" (druggist)		Facial neuralgia	After			Druggist	Chloroform habit			
3	"	"		Asthma	"	One ounce		Dr. W. B. Slayter	Delicate, chlor. habit			
4	"	"	40	Amputation of thigh			Towel	"		Stertorous breathing	Collapse after operation	
5	"			Fistula	During			"Qualified man"				
6	"	Mrs. Adams	33	Extraction of teeth								Evidence at inquest showed more than usual precautions had been taken.
7	Apr.	Mr. Goddry (chemist)		Necrosis of leg-bone	"	Exceptionally small		Chemist				Heart ceased to beat in three minutes after first inhalation.
8	"							At infirmary, England			Disease of the heart	
9	"							In hospital, "			"	
10	"	Female		Epithelioma of tongue	During	Two ounces	Squibb's bot., later a napkin	Prof. Squibb, America		Patient fainted	"Direct poisoning of nervous centres" (Squibb).	
11	May	Child	6			Two drachms	Towel	N.Y. Eye & Ear Inf., "		Ceased to breathe	Collapse	Right heart dilated, kidneys and spleen enlarged, lungs collapsed (time from first inhalation, fifteen minutes).
12	July	Male		Fistula in ano	Before	One drachm		Dr. Proctor, "			Collapse	Fatty degeneration of heart; death after not more than five inspirations.
13	"	Chinaman		Comp. fracture of leg	"	Large amount	Carelessly	"				Death before operation.
14	"	John Gray	17	Fracture of humerus	"	Ten drachms given in 10 min.	Towel	"	"Hard drinker"	Pulse failed and resp. ceased		Great congestion of veins of neck and head, brain healthy.
15	"	Chinaman		Tumor of neck	During			"				
16	"	Female			" (?)			"				
17	Aug.	Male	30	Amputation of hand	Before		"Usual way" (?)	Dr. Hudson, "	"Robust soldier"	Stertorous breathing	"Paralysis of the heart"	Negative.
18	"	"	40	Dislocation of shoulder	"			"	"Intemper. habits"	Face livid	Asphyxia	
19	Nov.	"	15		"		Towel	"	Anæmic	Conv. movements of lower extremities, dil. pupils, &c.		
20	"	"	25	Amputation of finger	During	Small amount						Fatty degeneration of heart, rupture of spleen, and blood in peritoneal cavity.
21	"	"			Before	Fifteen or twenty drops	Piece of lint	Dr. Ross, England				
22	Jan. '70	Female		Headache				America		Pulse stopped		Pus on surface of the brain and slight enlargement of heart.
23	Feb.	Male				One drachm		Middlesex, England				Endocarditis, granular degeneration of left ventricle.
24	Mar.	" (J. P.)				"				Pulse stopped		
25	Apr.	Female	22		Before			Sir J. Simpson, England	Thin, emaciated		Shock	Negative.
26	"	"	24		During			Prof. Billroth, Austria				Vegetations on valves of heart; pulse stopped before respiration stopped.
27	May	"	36	Extraction of tooth	"		"Sitting posture"					
28	July	Male	12		Before	Six minims						Fatty degeneration of heart; death in six minutes.
29	"	"	42		During		Administered rapidly					Disease of the heart and kidneys.
30	Dec.	Female				Two drachms		America				Fatty degeneration of heart.
31	"	"		Extraction of teeth	During							Death in five minutes.
32	Feb. '71	Twelve cases			"							
44	Mar.	"			"	Two drachms (Squibb's)		Dr. W. W. Dawson				
45	"	Male	28		"							
46	"	"	52		Before	One drachm and one-half						Fatty degeneration of heart.
47	May	Boy	11		"	Two drachms						Death in a few minutes.
48	June	Male			"			Germany				Negative; death in six minutes.
49	Aug.	Boy	8		"		"Lying on abdomen"					
50	Oct.	Female	13	Extraction of teeth	During	Four drachms		Dentist				Died in a few minutes.
51	"	Lieut.-Col. Rogers		Fracture of leg	"							
52	Nov.	Male	34		"							Instant death.
53	Jan. '72	"	33		"						Shock	Heart dilated, fatty liver and kidneys, brain softened.
54	"	Female	18			One drachm						
55	"	Male	37		During							
56	"	"	53		"							Fatty degeneration left ventricle.
57	May	"			"	Two drachms						Heart fibres granular.
58	"	"	22									Heart fatty.
59	June	"	48	Cataract	During	Two drachms			Chloroform habit			
60	Aug.	"	36		Before						Heart hypertrophied & fatty	Death in five minutes.
61	"									Paralysis of heart		" two "
62	Oct.	Male	53	Amputat'n at hip-joint	During			Billroth, Austria				
63	Nov.	Female	70	Dislocation of knee	"							
64	"	Male	31		"							
65	Dec.	"	60		Before	One drachm						Granular degeneration of heart, valves healthy.
66	"	"	45		During	Three drachms						Death in ten minutes.
67	"	Female	53	Tumor of head	Before	One drachm						Heart empty, mitral valves thickened; atheromatous arteries.
68	Feb. '73	Male	49	Fracture of leg	"							Death in one minute.
69	"	"	28	Crushed thumb					Intemperate man		Diseased heart	
70	"	"	35	Amputation of thigh	During							
71	Apr.	"	51	Comp. fracture of leg	"							Death in ten minutes.
72	"	Female	45	Tumor of neck	"							While dressing a compound fracture of the leg.
73	May	Boy	15		After	Two drachms						
74	June	Man	30	Fissure of anus	"						Syncope	Viscera healthy.
75	July	"	60	Introduct'n of catheter	"				Good health			
76					During			Dentist without degree, France				Verdict, "Involuntary Homicide;" one month imprisonment, fine £20 12s.
77	Oct.	Man		Diseased tibia	"							
78	Nov.	"	37	Enlarged liver	"							Heart flabby and hypertrophied; death in one and a half min.
79	"	Female	45	Fracture of wrist	"	Two drachms					Shock	Heart healthy; liver large and lardaceous, containing gummatous masses.
80	"	Male (physician)	45		After	Twelve drachms					Shock	
81	Dec.	"	44	Dislocation of shoulder	During		Towel		Chloroform habit			
82	Jan. '74	Female		Extraction of teeth	Not given							Blood more fluid than normal, left ventricle contracted, right relaxed, valves healthy.
83	Mar.	Male		Epithelioma of lip	During			Hospital, England				"Jury cautioned public against inhalation of such dangerous agents."
84	"	Female		Cancer of breast	"			"				
85	"	Male		Stricture	"	Two drachms	Sponge	Infirmary, "	Heart sounds normal			Right side of heart gorged with fluid blood, otherwise healthy; lungs deeply congested.
86	July	"		Dislocation of shoulder	"	One drachm (Squibb's)	Napkin					
87	"	"		Tumor of groin	"							
88	Aug.	"		Adenoid growths in posterior nares	"							
89	Sep.							Hospital, England				
90	"							Infirmary, "				
91	Jan. '75	Male		Extraction of tooth	During				Strong, healthy man			No cardiac disease, blood fluid throughout body. "Jury recommended enactment to prohibit its use."
92	"	Female		" "	"			England				
93	Mar.	Male		Asthma and toothache	"			Self administration				
94	May	"		Ampn'n of little finger	"							
95	June	"		Extraction of teeth	"	One half ounce			Healthy man			Death during struggling stage.
96	Jan. '76	Mrs. Childs										Death in five minutes.
97	Feb.	Male	12		During	Two drachms						
98	"											No disease of heart or of any internal organ.
99	Mar.	Male	23		During	Two and a half drachms						
100	Apr.	Jeremiah Tooth			"	Three drachms			Heart normal			
101	May			Extraction of teeth	"						Paralysis of heart	Enlarged heart and other evidences of disease.
102	"				"	One and a half drachm		Dentist, England				Verdict, "Death from Misadventure."
103	June	Female		Parturition	Before			Hospital (Sister), France	Heart's action norm'l			
104	Nov.											Death in ten minutes.
105	"							England		Violent struggling	Collapse	Fatty degeneration of heart.
106	"							"		"	"	" " "
107	Dec.	Female	30	Extraction of teeth	During				Full stomach	Vomiting	Asphyxia	Vomiting, followed by deep inspiration, and food was drawn into trachea; tracheotomy of no avail.
108	"	Male		Ext. of thorn from foot	"							
109	Jan. '77	Dr. Gustav Judell		Sleeplessness	"			Self administration		Vomiting	Asphyxia	Food in trachea from vomiting; patient too fully narcotized to eject it.
110	"	Boy	14	Extraction of tooth	After		Napkin					
111	Feb.	Female	29	Parturition	"			Dr. Colling		Tremor occurred	Collapse	
112	Mar.	Twenty cases						Dr. Chas. Anderson, Amer.				Over twenty cases in Cincinnati and its vicinity within the last thirty years. Clinic, March 31st, 1877.
132	Apr.	Male	52	Strangulated hernia	After	Two drachms		Mr. J. H. Wilson, England				London Lancet, February 10th, 1877.
133	"			Carcous bone fr. stump				"				Patient had taken ether safely at previous operation. British Medical Journal.
134	"			Ampnt'n of fore-finger				Hospital				
135	"	Female		Tumor of throat	Before							
136	May	Male	50	Fistula in ano	"			Infirmary, England		Resp. irreg., strug. violently		
137	"	Boy	8					"				
138	"	Dr. Chas. A. Jourdan		Extirpation of eye				America				American Journal Dental Science, May, 1877.
139	June	Male		Perineal fistula				Infirmary, England				London Lancet, June 9th, 1877.
140	"							Hospital, "				"Heart fatty." British Medical Journal, June 30th, 1877.
141	"	Mons. Bachlet		Toothache			Swallowed	France				Union Medicale, June, 1877.
142	Aug.	Female	27	Uterine trouble	Before	Few drops		Hospital, Canada			Collapse	Fatty degeneration of the right ventricle. Canadian Journal Medical Science, August, 1877.
143	"	Sarah Crudge	23	Strabismus operation				England				British Medical Journal, August, 1877.
144	"	Boy	12	Talipes				Hospital, America				Toledo Medical and Surgical Journal, August, 1877.
145	Sep.	Male		Irreduc. paraphimosis			On lint	" England		Face livid	Collapse	Heart flaccid and fatty; death in two minutes.
146	Dec.				During			South Wales				London Lancet, December, 1877.
147	Jan. '78				"			Canada				Fatty degeneration of the heart. Canada Lancet.
148	Feb.	Female		Extraction of teeth	"			Dentist, America			Spasm	Negative.
149	"											British Medical Journal.
150	"											Medical Times and Gazette.
151	Mar.	Mrs. Wm. Neely		Extraction of teeth	During	Half ounce	Napkin	Dentist—Dr. H. G. Winslow, America	Delicate health			Heart soft and flabby. Evening Telegraph, Philadelphia, March 22d, 1878.
152	Apr.	Female	31	" "	Before							Fatty heart. (?)
153	May	Male	11	External perineal urethrotomy	During	One ounce	"Carefully and judiciously"	Dr. McGuire, America	Prostrated by sickness		Caused by chloroform	Nitrite of Amyl used. Virginia Medical Monthly, May, 1878.
154	June	Boy	16	Congenital phimosis	"	Two drachms	"Carefully"	Dr. A. J. Parsons, "			Chloroform poisoning	Nitrite of Amyl, electricity, etc., used. St. Louis Medical and Surgical Journal, June, 1878.
155	Oct.	Geo. Dobson	18	Iridectomy for glaucoma	"	Three drachms	Two drachms the day before	Dr. J. G. Brooks, "			Collapse	Patient had been carefully examined. Large laminated heart-clot; "great caution and utmost skill;" death in 15 minutes. American Medical Bi-weekly, October, 1878
156	"	Female	38	Dislocation of elbow joint	"	Forty drops	Towel	Hospital, England	Heart examined and considered all right		"	Heart fatty.
157	Nov.	Henry Kohn	3	Malformation	"			" "	Weakly child		"	Lungs had never been fully inflated. Verdict, "Death from chloroform poisoning, and there is no blame attaching to the hospital authorities."
158	"	Female	22	Parturition, primipara	"			Dr. Cotting, America			" (giving of chloroform)	
159	"	"	25	" multipara	"			Hospital, "			"	Patient died in ten minutes.
160	Dec.	Male		Hydrocele	"	Fifteen to twenty grammes		Prof. Dumreicher, Austria			"	Negative. Allg. Wien. Med. Zeit., December 24th, 1878.

In all cases where the Journals referred to are not mentioned, the cases will be found reported in the "Medical News and Library," Philadelphia, of a corresponding date.

and all the known means employed to prevent death. There are also a large number of deaths unreported which, like fatal operations in surgery, never see the light of day, and are therefore of no use to warn the careful observer.

The number of deaths from chloroform, contained in the accompanying table, which have occurred up to date,* numbering one hundred and sixty, when added to the two hundred and ten † before reported, make the ghastly sum total, reported and fully authenticated, of *three hundred and seventy.* It will be seen, by a glance at the table, how and why deaths from chloroform have occurred; and how unsatisfactorily, in most of the cases, the facts connected with the circumstances have been reported.

COMMENTS UPON THE TABLE OF DEATHS FROM CHLOROFORM.

Date when Death occurred from Chloroform.—The number of deaths in the cold months were forty-seven, and against this we have forty-seven deaths during April, May, June, July, and August, showing but little difference in regard to temperature.

Sex.—We find there are seventy deaths in males, and twenty-nine in females. Our results agree with those of Sansom.

Age.—Number of cases over twenty-one, fifty-six; under it, nine, the youngest of which was three (No. 157), then follows one at six, eight, eleven, twelve, fourteen, fifteen, sixteen, and eighteen years.

Character of the Operation for which the Chloroform was administered.—In many instances the chloroform was employed for trifling ailments, which could have been relieved by less hazardous means, or in surgical operations of minor importance, as follows: facial neuralgia, asthma, headache, toothache, sleeplessness, uterine trouble, etc. Of the operations, there were fourteen cases of extraction of teeth; then follows introduction of catheter, extraction of thorn, amputations of fingers and toes, hydrocele,

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* The author desires to acknowledge his obligations to Dr. C. S. Turnbull for valuable assistance in the preparation of this table, also to Dr. H. F. Sterling for collecting cases.

† Medical News and Library, Philadelphia, up to 1869.

removal of dead bone, dressing of fractures, tumors of small size, fissure of anus, cataract, iridectomy, and strabismus; many of which could have been performed without an anæsthetic, or if this was insisted upon, sulphuric ether, hydrobromic ether, or nitrous oxide, could have been employed.

THE TIME AT WHICH THE PATIENT DIED.—In twenty-four instanees before the operation, sixty-one during, and only ten after the operation.

THE QUANTITY OF CHLOROFORM EMPLOYED. — The smallest quantity employed was a few drops in case No. 142; then in case No. 21 fifteen to twenty drops, in case No. 156 forty drops, case No. 28 six minims, and in eight cases one drachm only was employed; in twelve cases, two drachms; from half an ounce to one ounce in most of the other cases, with one exception, in which it was stated a large amount, in case No. 20, was employed.

FORM OF APPARATUS.—In nine cases a towel or napkin was used; in two, upon lint and sponge; one in the sitting posture; in one, large amount carelessly administered; one lying on abdomen.

CONDITION OF PATIENT.—The first most prominent condition of a patient was the habitual employment of chloroform (three), either to induce sleep, relieve pain, or in most instances as an intoxicant, at first in moderate quantity and then increasing it, forgetting its fatal nature. The second condition was its fatal effects upon persons of an intemperate habit (three), anæmic (two), or disease of heart, or broken down in general health. On the other hand, however, many are cut down in a perfectly healthy condition, after the heart has been examined and considered all right (five).

SYMPTOMS.—The most prominent symptoms of chloroform poisoning will be found to be the fainting of the patient, failure of the pulse, heart's action, and ceasing of the respiration, stertorous breathing, face livid, convulsive movements, and dilatation of the pupil.

THE CAUSE OF DEATH.—Out of twenty-seven cases, the majority of deaths is stated to be from collapse (in fourteen cases), from shock (two), syncope (one), asphyxia (three), from disease or paralysis of the heart (five), chloroform poisoning (two).

POST MORTEM APPEARANCES.—Heart affections seem to

have been the chief causes for death reported. Fatty degeneration of the heart was found in seventeen cases; other cardiac lesions, nine cases. An examination of our table will prove the sad but positive fact that a large number of patients who die from chloroform were healthy prior to taking the fatal dose to relieve them of some trifling ailment or for a minor surgical operation. (The results confirm the experiments of Schiff, who stated that in more than five thousand cases that chloroform paralyzes the heart and blood vessels at once without previously paralyzing the respiration.) Thirty cases were either healthy, or *post mortem* results were negative; in one case the patient had been carefully examined, and no disease of heart or lungs was found to exist; one had inhaled chloroform the day before. In two cases, from vomiting, followed by deep inspiration, the food was found drawn into the trachea ; in one, tracheotomy of no avail; in the other case, patient died alone (self-administered). In many of the cases the *post mortem* conditions are given in detail, as though they were pathological changes.

CHLOROFORM GIVES BUT LITTLE WARNING!—The rapidity with which patients die from it is as follows:—

1	patient,	instantly, struggling stage, . .	died in	1	second.
1	"	suddenly, ...	"	$1\frac{1}{2}$	minute.
1	"	. . . .	"	2	"
1	"	. . . .	"	3	"
4	"	. . . .	"	5	"
1	"	. . . .	"	6	"
4	"	. . . .	"	10	"
2	"	. . . .	"	15	"
2	"	. . . .	"	a few	"

Schiff also confirms the results in this table, as he, too, has found death to occur from chloroform at the first inspiration.

NITRITE OF AMYL ($C_5H_{11}NO_2$).

This valuable drug was discovered by Balard in 1844, and within the last few years nitrite of amyl has assumed considerable importance as a remedy in all spasmodic affections, and as an antidote to chloroform poisoning. The first notice

of its effects was by Professor Guthrie, who, while distilling nitrite of amyl from amylic alcohol, observed that the vapor, when inhaled, quickened his circulation, and made him feel as if he had been running. There was flushing of his face, rapid action of the heart, and difficult breathing.

Perfectly pure nitrite of amyl can only be obtained by many careful distillations. It boils constantly at 96° C., while specimens examined by Dr. Greene, of this city, were found to have boiling points ranging between 60° and 180° C. Such products, he observes, have never been rectified; one specimen had not entirely distilled at 220°; another contained about ten per cent. of water, twenty-five per cent. of amyl nitrite (90° to 100° C.), and the remainder was composed almost entirely of unaltered amylic alcohol.

If the nitrite of amyl is made from amylic alcohol, it should be that which passes after two or three fractionations between 128° and 132° C., the difficulty of not obtaining it pure enough being due to a faulty process or carelessness in its rectification.

A very fair yield of nitrite of amyl may be obtained by the action of potassium nitrite and sulphuric acid. The potassium nitrite may be easily made by maintaining potassium nitrate for some time at a dull red heat. It is then heated with amylic alcohol in a flask on a water bath, and sulphuric acid, diluted with its volume of water, gradually added. The nitrite of amyl distills over regularly with some vapor of water. After washing the product with a solution of potassium carbonate, and drying it with solid potassium carbonate, it is again distilled, and all that passes below 100° C. may be retained.

Four ounces of commercial nitrite re-distilled by Dr. Greene, to obtain for me a pure specimen, yielded less than one ounce. This accounts for the very variable effects observed by the different observers. For my part, I have, at times, been very much disappointed in it, and on examination of the drug, obtained from a first-class store, it was found to be amylic ether, with only a small proportion of the nitrite of amyl.

The same difficulty is experienced in Great Britain in obtaining pure nitrite of amyl, as may be seen by the following:

"The purity of this drug was discussed before the British Pharmaceutical Society, in September, 1878, by Mr. D. B. Dott. His paper embodied the results of an examination of several samples of nitrite of amyl procured from different makers, with the view of ascertaining the degree of purity of the article in the market. The samples examined had a specific gravity varying from .864 to .876, the proper specific gravity being .877. By a single rectification they gave a yield of 6.7, 11.5, 33.3, 47.5, and 65.0 per cent. respectively, boiling at 90° to 100° C., while a sample prepared by the author in the ordinary way gave 85.0 per cent. One of the samples had an odor quite distinct from that of genuine nitrite of amyl, and produced little effect on the heart's action by the inhalation of its vapor. It will thus be seen that there is a great variation in the quality of the amyl nitrite of different makers, and that some of it is of very inferior quality. The author considers that some standard of purity less rigid than that of the Pharmacopœia ought to be adopted, as it is impossible to prepare a nitrite of amyl boiling constantly at 205° F. Indeed, there seems to be some doubt as to whether that is really the correct boiling point. The process for preparing nitrite of amyl by passing nitrous acid gas through amylic alcohol is held to be the best, being decidedly preferable to that by the direct action of nitric acid on the alcohol."

EFFECTS OF NITRITE OF AMYL.

There is a very great difference in the effects which nitrite of amyl, chemically pure, produces in different persons. I know of two persons who cannot approach it without immediately experiencing a feeling of distress in the region of the heart, accompanied by a sense of faintness. Another, after one whiff, swung around, and would have fallen to the ground if support had not been at hand. In my own case, I can inhale it with impunity, and it requires five to ten seconds before flushing of the face, disturbance of the heart, or giddiness are induced.

When first employed it was with the greatest amount of care, and was supposed to be very dangerous, but we have not found it to be so, nor have we as yet known of a single death from it, when used as a therapeutic agent.

In a case of spasm of the glottis, following pneumonia, I employed inhalations of the nitrite of amyl, in the form of the glass globules, "pearls of nitrite of amyl," with success, much to the relief of the patient.

While traveling during the summer of 1877, I met a well-known gentleman of Philadelphia, the late Mr. E. Bonsell,* who was affected with angina pectoris. A vial of nitrite of amyl was his constant companion for several years. Every little while he would inhale its vapor with decided benefit and relief. He had done so for many months without the least deleterious effect.

In another case this remedy completely failed, and hypodermic injections of morphia had to be resorted to during the attacks.

In most of cases it is best administered lying down. Women are more susceptible to its effects than men. Given internally, with mucilage and an aromatic, it will at times produce nausea; generally an irritation of the throat. This is increased by the impurity of the drug.

Taking into consideration the different idiosyncrasies and susceptibilities, it is better in all cases to begin with the minimum dose, say one drop, and gradually increase if well tolerated. It should never be trusted to the patient until its effects upon his system are well known.

NITRITE OF AMYL AS AN ANTIDOTE TO CHLOROFORM.

Dr. Burrall, of New York, has recapitulated the experiments performed upon cats and dogs by others and himself, and set the amyl down as an agent which should always be in the armamentarium of the medical man, who went prepared to meet any emergency that might arise while producing anæsthesia with chloroform.

Dr. W. L. Lane has repeated numerous experiments on animals with the nitrite of amyl, and states: "When inhaled in small quantities, it produces recovery from chloroform insensibility by dilating the arterioles of the brain, and thus removing the cerebral anæmia due to the chloroform. It also helps to produce recovery from the chloroform in-

* He died at the advanced age of eighty-two during 1879.

sensibility by raising the temperature, which is always lowered by chloroform, and by removing the paralysis of the heart due to chloroform. This action is well seen by the nitrite of amyl making the heart's beats fewer and sounds louder. This action of the nitrite of amyl in flushing the face and eyes, causes increased heat, and makes the heart beat slower, but with an irregular action, as we have experienced in our own person, in doses of two mimims and a half by inhalation."

Dr. Lane also states, by way of caution, that where the pure nitrite of amyl is inhaled in large quantities, instead of producing recovery from chloroformic insensibility, it not only retards it, but it may cause death by paralysis and over distension of the heart and engorgement of the venous system. In large doses (inhaled) it produces a fall of temperature.

FIVE SUCCESSFUL CASES OF RESUSCITATION OF THREATENED DEATH FROM CHLOROFORM.

Dr. Mundé, in *American Journal Medical Sciences*, January 4, 1878, states: "The beneficial effects of nitrite of amyl in stimulating the heart, and thus permitting the continued administration of ether (in an operation for ovariotomy), were witnessed by all the physicians present, and are unquestionable. He also states that two cases of resuscitation from chloroform syncope by amyl-nitrite have been reported by Dr. Pilcher in his report on croup and diptheria; and very recently* I find a case published in which the inhalation of the nitrite of amyl, which fortunately was at hand, according to the testimony of physicians present, revived the patient from sudden chloroform collapse, and saved her life."

The editor of the *British Medical Journal* says: "We have received the following interesting report for publication from a physician:—

"On the 9th instant I was asked by a professional friend to administer chloroform to a patient of his, from whom he was about to remove a fatty tumor situated in the left lumbar region. The patient in question was about forty-nine

* British Medical Journal, August 18, 1877.

years of age, married, the mother of several children, of thin, spare habit, but otherwise in good health. She was nervous, and apprehensive of the result, entreating me not to give her too much chloroform. Having previously examined the heart and found all sounds normal, I gave her about two teaspoonfuls of brandy undiluted; and after waiting a few minutes and placing her in a recumbent posture, I commenced the administration. The chloroform I used was Duncan & Flockhart's, upon the purity of which we can always depend. I poured a measured drachm upon a piece of lint enveloped in a towel. I held it some little distance from her mouth and nose, and let her inhale slowly. My friend noted her pulse, whilst I carefully watched the respiration. The first dose did not produce any effect, and I then used another drachm, which soon caused a good deal of excitement, incoherent talking, and struggling, the patient striving several times to snatch the inhaler from my hand. This gradually subsided, and she appeared to be passing into the third stage of anæsthesia, when she made an abortive attempt to vomit, raised her head from the pillow, and, to my friend's great alarm, the pulse flickered and stopped altogether. She gave a gasp, foam gathered on her lips, her jaw became rigid, and to all appearance she was dead. I immediately withdrew the chloroform, my friend dashed some cold water in her face and pulled her tongue forward, whilst I commenced artificial respiration, after Marshall Hall's method, but without success. We then poured some nitrite of amyl on lint, and held it to her nostrils. In such emergencies it is impossible to judge the flight of time correctly, but I should say in ten seconds there was a flushing of the face, the pulse was again felt, and, to our great joy, the all important function of respiration was again restored, the woman being rescued apparently from the very embrace of death."

An English journal reports a case of threatened death from chloroform, in which the patient was resuscitated by the inhalation of a few drops of nitrite of amyl. The indication for the use of amyl is furnished by the sudden failure of the pulse.*

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* Medical Record, May 25th, 1878.

A case of the successful use of nitrite of amyl in a case of chloroform narcosis is reported by Doctor Rufus R. Hinton, in the *Philadelphia Medical Times*, of January 31st, 1875.

DEATH FROM CHLOROFORM NARCOSIS.—FAILURE OF NELATON'S METHOD, AND OF THE AMYL NITRITE TREATMENT.

Dr. Hugh M. Taylor, of Richmond, Virginia, reports the following case in the *Virginia Medical Monthly*, of May, 1878:—

"Professor McGuire has requested me to report the following death from chloroform, which occurred a few days ago in his practice. As far as I can learn, it is the second death from this agent which has occurred in our city, and is one of the very few recorded by our Southern surgeons:—

"The patient was a gentleman from North Carolina, æt. 41 years. Twelve or fourteen months ago he received a violent blow upon his perineum by being thrown upon the pommel of a saddle. His urethra was ruptured; this was followed by urinary infiltration, abscesses, resulting in the loss of the entire penis, and part of the scrotum. Since that time he has been a very great sufferer, and had become entirely dependent upon anodynes, frequently taking as much as two grains of the sulphate of morphia a day. During the last six months of his sickness, he has spent most of his time in bed or in the recumbent position.

"On the day of operation, April 20th, 1878 (Doctors Cunningham, Ross, Leech, Maclin, and Carroll co-operating), Squibb's purified chloroform was administered, for the purpose of making a direct outlet for the urine by external perineal urethrotomy. The administration of the anæsthetic was begun while the patient was in his bed. He was then put upon a table in the lithotomy position, and the table was drawn near an open window, occupying a position directly between the open window and an open door. I noticed, when giving him chloroform in his bed, that he was not easily brought under its influence. Some delay occurred in the first part of the operation in consequence of the extensive undermining of the tissues and burrowing of the urine and pus, leaving a great number of false passages, and rendering it tedious to get a guide of any sort into the

bladder. During this stage of the operation, he was not kept fully under the chloroform. After some effort, the continuation of the urethra was found, and an instrument passed into the bladder. The administrator then carried the anæsthesia far enough to allow the operation to be finished. He had done this, and had taken the chloroform away for a few seconds, when we were all startled by one or two stertorous respirations, and then followed an entire cessation of respiratory effort.

"In less time than I can tell it, his tongue was drawn forward with a tenaculum; his feet were raised, and his head was lowered; water was dashed in his face; his cheeks smacked; nitrite of amyl held to his nose. As none of these aroused him, he was quickly placed on the table and artificial respiration resorted to. Dr. Ross and I raised and depressed his arms, while Doctors McGuire and Cunningham compressed his thorax. Let me here remark that I am sure in this case the death was not from asphyxia or the impregnation of his blood with carbonic acid. The efforts at artificial respiration were eminently successful. As the arms were raised, the air rushed into his lungs, producing a stertor as natural as life—and then when the thorax was compressed, the blowing sound of exit was plainly heard. Indeed, these artificial inspirations and expirations were so strikingly normal as to deceive me for some time into believing them vital. During this time whiskey was injected into his rectum; amyl occasionally held to his nose, and the foot of the table elevated. Only once during our prolonged efforts to resuscitate him was there the least token of returning animation, and that was when the first dash of cold water struck his face. Then he gasped feebly—but once. His features from the first were blanched and bloodless; he carried to his grave the finger marks produced by slapping him; his pupils were both widely dilated; his lips blue. He had been under the influence of chloroform for about three-quarters of an hour—at no time very profoundly. During this time he took about ℥j of Squibb's purified chloroform. The large quantity of anodynes which he had accustomed himself to, and the extreme sensitiveness of the parts manipulated, rendered it difficult to anæsthetize him. He had taken chloroform twice before he came to the city,

and this latter trouble, viz., inability to completely affect him, was noticed upon both occasions.

"In reviewing the case, we conclude that death was brought about through syncope; that amyl had no effect in replenishing the anæmic blood vessels of the brain; and that at least one case has happened when its antidotal virtues were not at all noticeable; that the result was of sudden occurrence, and of speedy termination; that his pulse was good a very few seconds before, and that the artificial respiration would have oxygenated any quantity of carbonized blood with which his lungs might have been surcharged; that the administrator was in no manner to blame, as he fulfilled his part with the utmost care and skill. The verdict of all present was 'that death was caused by chloroform; but that the same was carefully and judiciously administered.'"

Being desirous of knowing some obscure points in regard to the way in which the nitrite had been used, I wrote to Doctor Taylor, addressing the following questions:—Did the nitrite of amyl produce a flushing of the face, action of the heart, and difficult breathing when you employed it yourself? Did you use a tube to force it up the nostrils when the breathing had ceased? How many drops were employed? Was it in capsules or dropped from a bottle?

The Doctor kindly replied as follows:—

RICHMOND, May 31st, 1878.

DOCTOR TURNBULL,

DEAR SIR:—Your letter, dated May 20th, found me out of the city for a few days. I am very glad to answer your inquiries. You say that "Professor Nélaton's method will sometimes fail, especially when morphia has been used with the chloroform." No morphia was given at the time, with the chloroform. It was during his sickness that large quantities had been administered. In regard to the amyl used, it was made by Squibb, and was, I think, pure. I am sorry I cannot find a sample of it to send you for examination. It was dropped from a bottle upon a handkerchief. The number of drops were not ascertained. No tube was introduced into the nose.

Very respectfully, etc.,

HUGH M. TAYLOR.

DEATH FROM CHLOROFORM IN WHICH THE NITRITE OF AMYL WAS EMPLOYED WITHOUT SUCCESS.

Death from chloroform April 29th, 1879, by W. P. Mills, M. D.,* of Brownsville, Mobile. I was requested to operate on a boy aged 16 years, for congenital phimosis. He was chloroformed by Dr. A. J. Parsons, who has often administered chloroform by inhalation, and, by the way, he is very cautious in the administration of this potent drug. Notwithstanding the great prudence, caution, and the general manner in which it was administered, just as the operation was completed, and without any indication of danger whatever, instantaneously—almost as quick as the explosion of gunpowder—respiration ceased, and a livid color overspread his face, and in spite of all the usual restoratives, he was soon dead; in fact it seemed as if he was struck dead in an instant. Immediately, upon the supervention of these alarming symptoms, his head was lowered, cold water thrown into his face, and artificial respiration induced. Under the influence of this treatment some improvement was manifested, and for a few seconds it seemed that the danger was over, but suddenly all the alarming spmptoms before described were again exhibited, and death was the inevitable result. Not more than three drachms of chloroform was used, and of this not more than one and a half or two drachms were actually inhaled, and the patient was not deeply under its influence at any time during the operation, which, as a matter of course, was very brief. Nitrite of amyl, electricity, and hypodermic injections of whiskey were all brought into requisition, but, as the sequel proved, were of no avail. The most noteworthy feature of the case was the very sudden supervention of the alarming symptoms, for according to my information in regard to chloroform poisoning, there is generally some warning given of its deleterious influence."

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* Saint Louis Medical and Surgical Journal, June, 1878, p. 492.

NOTE.—I do not think the doctor was justified in the use of so powerful an anæsthetic to risk his patient's life in so trifling an operation. Evidently the nitrite of amyl was not employed until the patient had become unable to inhale it. The conclusions are not the most recent, as a careful reading of our table of deaths from it, will show. It gives but little warning before it kills the patient.

PHYSIOLOGICAL EFFECTS OF NITRITE OF AMYL.

In 1861–2, Dr. B. W. Richardson, of London, made a careful and prolonged study of the action of this singular body, and discovered that it produced its effect by causing an extreme relaxation, first of the blood-vessels, and afterwards of the muscular fibres of the body. In 1863 Dr. Richardson employed it as an anæsthetic, but soon discovered that it was not a true anæsthetic; nor does it produce unconsciousness until its other effects are fully developed,—a feeling of sickness and distress. The blood in both sets of vessels acquires a brownish color. At first it quickens the respiration, but its prolonged use retards the movements of the chest and lowers animal temperature. According to the experiments of Droz,* when it causes death in the lower animals, the first effect is great restlessness. The animal sneezes and struggles to get away; the respiration becomes quickened and fuller, and occasionally stops. Following this are alternating tonic and clonic contractions in the extremities, and even the face; then opisthotonos, shivering, involuntary excretions, vomiting and coma. Post mortem results are not very marked, except the dark color of the blood and the dilated, engorged heart, death being produced apparently by paralysis of this organ. To such an extent did this agent relax, that it would even overcome the tetanic spasm produced by strychnia, and relieve the most agonizing of known human maladies,—*angina pectoris*. Even tetanus has been subdued by it in two instances. In asthma, my own experience coincides with that of others that it will, in certain spasmodic forms, instantly arrest the paroxysm. An exceedingly convenient mode of carrying the drug is by means of thin glass globules of nitrite of amyl, containing respectively ♏iiss and ♏v. When required, one of the bulbs is broken in a handkerchief or towel, and its contents immediately inhaled. I have employed this agent in spasmodic ear cough, also in tinnitus aurium, in which there is spasm of the muscles of the ear bones, or spasmodic contraction of the capillaries,

* Arch de Physiologie, Sep., 1873. Translated by Dr. F. Woodbury, Medical Times, Nov. 22, 1873.

in which case I directed the patient to carry a small glass-stoppered bottle, and to inhale five or six drops on a handkerchief, or even hold the nose for a second to the mouth of the bottle containing a small quantity.

In an article by Dr. Aug. Ladendorf,* writing from the Sachsenberg Lunatic Asylum, where his observations, embracing more than forty cases, were made, partly upon sane persons and partly on those recovering from different psychoses. The time selected was generally from three to five, p. m., or after eight p. m., thus avoiding times when a normal rise of temperature might be expected. The thermometer was placed in the mouth, between the cheek and the superior maxilla,—a space almost shut off by the tongue from the nasal respiratory tract. The readings were made by the help of a lens magnifying six times, so that by using a thermometer divided into tenths it was possible to recognize, without much chance of error, $\frac{1}{100}$th of a degree Centigrade, equal to $\frac{1}{55}$th of a degree of Fahrenheit nearly. The general result is that the temperature always rises after the inhalation. Many circumstances affect the amount of this rise, such as the quantity of vapor inhaled, the surrounding atmosphere, the contraction of blood-vessels, individual peculiarities, etc. So that two persons with the same initial temperature may show differences of 0.53° C., equal to 0.95° F. It is, however, interesting that this rise can generally be demonstrated for from one to two hours, for this explains the beneficial and continued effects of the remedy in disease. A table of thirty-six cases is given, with the temperatures observed, the differences, their maxima and remarks. The smallest maximal elevation of temperature was 0.1° C., equal to 0.2° F. nearly (in three cases); the highest maximal rise was 1.88° C., equal to 3.38° F. (one case); the mean rise was 0.39 C., equal to 0.7° F. (thirty-six cases); or, in other words, the temperature rises rather more than half a degree Fahrenheit after the inhalation of nitrite of amyl. This elevation is very evident in the course of the second minute of inhalation. The purer the preparation inhaled, the more evident the effect. The effect on the pupils was not very uni-

* No. 43 of the Berliner Klinische Wochenschrift.

form. In all the cases when simultaneous observations were made, the axillary temperature rose correspondingly. Horatio Wood (*American Journal of the Medical Sciences*, cxxiii.) and Pick (*Ueber das Amylnitrit und seine Therapeutische Anwendung*, Versuch, 13) observed a fall of temperature in animals; but perhaps this resulted from the mode of experimenting. Hostermann's account of the pulse (*Wiener Med. Wochenschrift*, 1872, Nos. 46, 47, 48) is confirmed by these experiments. These effects probably have a common cause, not mere dilatation of the vessels.

In a careful examination of all experiments made with the nitrite of amyl on man, I have not met with a single case of death from it, owing, I think, to the great care with which it has been employed. Two cases are recorded by Sanders and Samelsohn of sudden collapse, skin cold, clammy, and pulse threadlike and slow, face pale, and yet consciousness was retained, and both cases recovered.

ON THE USE OF ATROPINE IN CHLOROFORM NARCOSIS.

Prof. J. A. Larabee,* of St. Louis, Ky., was called to see a patient who had inhaled one ounce of chloroform. The patient was seen four or five hours after, when in a state of collapse, and every known means had been resorted to to restore the heart's action, but all in vain. He injected one-tenth of a grain of atropine hypodermically. This partially restored the heart's action, and in one half hour's time the same was repeated; and still later, to stimulate the respiration, one-tenth of a grain of atropine was injected. Four hours later the pulse and respiration had recovered their tone.

ICE AS A MEANS OF PREVENTING NARCOSIS FROM CHLOROFORM.

Another means of treating threatening narcosis caused by chloroform is recommended by M. Baillée, of Belgium. It consists of the introduction of a small piece of ice into the rectum. A moderate degree of pressure suffices to overcome the resistance of the sphincter. The ice melts in the

* Medical Record, May 25, 1878.

intestine, and immediately excites a deep inspiration, which is followed by the re-establishment of natural respiration and of the cardiac functions.

NITRITE OF AMYL AND CHLOROFORM AS AN ANÆSTHETIC.

L. B. Balliet, in the *Medical and Surgical Reporter*, says:—

"In my practice of over twenty-four years I have, until recently, used chloroform as an anæsthetic in all surgical cases and convulsions of children. The past six months, with the object of lessening the dangers of asphyxia by this powerful anæsthetic, I added to the ounce of chloroform sixteen drops of nitrite of amyl. The result thus far is apparently most satisfactory. Nevertheless, further careful tests are needed to fully confirm my views of this combination as a safe anæsthetic. I therefore ask surgeons to give this a fair trial, and report their experiences in regard to its action on the heart, respiration and circulation, and compare it carefully with the symptoms produced when chloroform alone is used. I shall still continue the use of this compound anæsthetic, but may vary the proportions of the nitrite of amyl in particular cases."

Dr. George E. Sanford publishes in the *Medical Record* of October 5th, 1878, the following article on "chloramyl, a new anæsthetic, and an improved inhaler:"—

"Having had considerable experience in the administration of the various anæsthetics in use at the present day, viz., chloroform, ether, etc., and not feeling satisfied with the safety, or rather *unsafety* of chloroform, or with the many faults of sulphuric ether, which so nearly counterbalance its comparative safety as to preclude its use in favor of chloroform in many cases, I have therefore experimented with various compounds in the hope of discovering a new and better anæsthetic.

"Early in the month of April, 1877, while treating an asthmatic patient with the nitrite of amyl, I became impressed with the idea of augmenting the heart's action with this drug, and thereby *preventing* the tendency to syncope and asphyxia, from paralysis of the heart, in cases of chloroform narcosis.

"I then began a series of experiments upon animals, first administering chloroform and then the nitrite of amyl. Then I began to mix them for use, aiming to get such a proportion of the amyl as would just counteract the paralytic effect of the chloroform. I found that while pure chloroform (Squibbs') would mix readily with the nitrite of amyl, producing a fine, clear solution, the chloroform of other manufacturers was unsatisfactory, leaving a milky solution of unpleasant odor. Continuing my experiments, I came to the conclusion that a quarter of an ounce of the nitrite of amyl to the pound of Squibbs' chloroform was about the proper strength, and that the combination was far safer for general anæsthetic purposes than chloroform uncombined; indeed, in my hands, and in those of others, so far as tried, it seems to be fully as safe as sulphuric ether, and far more pleasant in its administration, possessing all of the advantages of pure chloroform, but without its dangers.

"Upon becoming satisfied of the value of my discovery, I named it chloramyl. I first administered chloramyl to persons in June, 1877, as follows:—June 6th, I administered the compound to Charles Detrick, a young, healthy man, for the purpose of dressing a badly crushed thumb, both the patient and bystanders being wonderfully pleased with its operation. Next, June 16th, I gave it for amputation of a finger; then, June 18th, for extraction of a tooth; since which time I have employed it (chloramyl) in a great variety of cases in both surgical and obstetrical practice. I find that patients usually take it better than chloroform alone, and so far there has not been the first indication of danger from its use. In exhibiting chloramyl the patient's face becomes flushed much sooner than with chloroform; but press the drug right along and the countenance does not become pale. Both the heart's action and respiration are kept up thoroughly throughout the anæsthesia. I have given this prescription to several physicians, and induced them to try the chloramyl, with the most satisfactory results. I have also (last month) communicated the same to Professors Maclean, Dunster, and Frothingham, of Michigan University; and have reported my discovery to the Cayuga County, New York, Medical Society.

"Having noticed lately several communications in the

columns of the *Record*, from Dr. F. A. Burrall and others, on the use of amyl nitrite as an antidote to chloroform in cases of poisoning, I concluded to publish my discovery. As Dr. Burrall states in his article in the *Record* of July 20th, 'With our present knowledge of the antidotal properties of amyl nitrite in relation to chloroform, it is but justice to our patients to have it at hand when chloroform is administered.' I agree with him that we should have it at hand, but not in a separate bottle, to use *after the danger has become imminent*, but (as it produces no ill effects) *mixed with chloroform*, in such a proportion as to prevent the approach of danger, by both syncope and asphyxia; for such I claim to be the effect of this combination, and as such I give chloramyl to the medical profession, asking that it may be given a full and fair trial, and trusting that it may become the humble instrument in other hands of saving human life. Not that I would detract from the honors due the inventor of chloroform, for it was a grand invention; but if we can relieve its administration from the embarrassment and danger which have heretofore attended its use, will it not indeed be a great boon to humanity?

"The formula I use for chloramyl is—

℞. Squibbs' chloroform, i ℔.
Nitrite of amyl, ʒii.—M.

"But I would suggest that the amount of nitrite of amyl be diminished in long and tedious operations, and on farther trial it may prove best to vary the proportions, the point aimed at being to use just sufficient amyl nitrite to counteract the paralytic effect of the chloroform."

Doctor F. A. Burrall a short time after expressed his opinion in the following words, alluding to Doctor Sandford's communication, and addressing the editor of the *Medical Record*:—

"The communication in your number of October 5th, 1878, from Doctor George E. Sandford, is of decided interest, both as affording a hope that the dangers of chloroform may be diminished, and also as related to one of the most interesting branches of practical medicine. I refer to the simultaneous employment of antagonistic drugs. Those who have read Fothergill's recent work on the Antagonism of Medicines will be impressed with the truth of the author's

remark that this counteraction of medicinal agents 'promises to be the most potent and, withal, the most precise subject connected with therapeutics.'"

In a paper read before the Southern Michigan Medical Association, July 13th, 1875, by W. N. Smart, M. D., of Hudson, Michigan, he thus refers to an experiment in which chloroform and nitrite of amyl were administered together, and which may be interesting in this connection:—

"Gave a half-grown kitten a *mixed vapor* of chloroform and nitrite of amyl, containing about forty-nine parts of the former to one of the latter. I gave this by placing chloroform and amyl, in the above proportion, in a thick cloth sack, which was drawn over the head and held close around the neck, the chloroform and amyl being renewed several times, in order to insure a strong vapor. The effect produced by breathing this vapor for fifteen minutes is a rapid, though deep inspiration; a rapid and rather feeble action of the heart; an inability to co-ordinate movements; a very slight degree of anæsthesia, and a species of intoxication resembling that produced by alcohol."

How far chloramyl will answer as a safe substitute for chloroform can only be determined by experiment. Since it is estimated that one death occurs in about twenty-five or twenty-seven hundred administrations of chloroform, it is evident that some time must elapse before the comparative merits of any new anæsthetic can be considered as established. For the present it seems to me that humanity and science alike require that when chloroform is used as an anæsthetic, the nitrite of amyl should be at hand as one of the remedies whose efficiency is to be tested in case of impending danger.

THE USE OF A MIXTURE OF OIL OF TURPENTINE AND CHLOROFORM IN THE PREVENTION OF CHLOROFORM NARCOSIS.

In the *Vierteljahrschrift für Gericht. Med.*, Doctor Wachsmuth, of Berlin, makes the important statement that if one-fifth part of oil of turpentine is added to chloroform, the latter can be administered to the fullest anæsthesia without the slightest risk, as the turpentine prevents, by its stimulating properties, the pulmonic paralysis, which is the proximate cause of death in fatal chloroform narcosis.

I employed this mixture in two cases, in which I could not use ether, and it answered the purpose very well, but as the operations were not protracted, further trials will be necessary, as in small doses it produces stimulation of the nervous system, but paralyzing effect when large quantities are administered.

THERAPEUTIC USES OF NITRITE OF AMYL.

Dr. S. Weir Mitchell of this city was the first to employ inhalations of nitride of amyl in epilepsy, and he reported a number of successful cases. Others have followed with results not quite as satisfactory. In our own cases we found it to be useful, but not curative. It modifies the intensity of the attacks, especially when they come close together.

Dr. Brunton first employed nitrite of amyl in angina pectoris, and found it more effective than any other remedy in this painful and dangerous disease. Since then it has been largely used with signal success, although in an occasional case the relief is only temporary.

At a discussion upon the effects of the nitrite of amyl, before the Medico-Psychological Society of Berlin,* Dr. Solger had used the nitrite of amyl in a case of unilateral clonic spasm in a child without success. Chloroform used in the same case caused the convulsions to disappear for some time. The effect of chloroform seemed to be antagonistic to that of nitrite of amyl. The vessels of the pia matter exposed in a rabbit under the influence of chloroform were seen to be contracted, while upon inhalation of the nitrite they became enlarged. Dr. Jastrowitz used the nitrite of amyl with good results in asthma, but in the case of melancholia and other forms of insanity without beneficial effect. Inhalation of the drug causes disagreeable dizziness. He would not, therefore, use it in cases of vertigo. His impression was that hyperœmia of the brain did not extend throughout that organ, since, in patients who had used the remedy for some time, hyperœmia of the optic papilla could not be observed either during inhalation or in the intervals. Dr. J. mentioned cases illustrating the danger sometimes attending the inhalation of the nitrite

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* Wein Medical Press, Feb. 28, 1875, and Medical Times, April 24, 1875.

and the necessity of caution in its employment. In these cases sudden collapse followed its use. He had subsequently met with Schuller's experiments, showing that a marked contraction of the vessels of the pia followed the usual dilatation. He had also observed that certain patients voluntarily alluded to the fact that objects appeared of a yellow color subsequent to the use of the nitrite.

In "flushings of heat," or "heats," which so frequently trouble women at the change of life, or caused occasionally by the sudden arrest of menstruation, the action of nitrite of amyl, according to Ringer, is very marked, preventing or greatly diminishing the profuse perspiration and consequent prostration. It is said to be useful in sick headache and in preventing sea-sickness. It is stated to have arrested a paroxysm of intermittent fever when inhaled during the cold stage in the dose of four drops. In a case also of syncope in a man affected with cardiac dilatation and hypertropy, the inhalation produced relief.

Doctor J. Michel, of Hamburg,* has made a series of experiments with this remedy, in tinnitus aurium, and came to the conclusion that it was especially suggested in that form accompanied by hypertrophic changes in the middle ear, and in affections of the labyrinth. He was led to employ this remedy from its well-known sedative action upon the sympathetic system, especially the vaso motor nerves, and the fact that many forms of tinnitus are caused not only by an increased intra-labyrinthine pressure, but occur as the result of nervous irritation, not only of the auditory nerve but in branches of the fifth, of a neuralgic character or trophic type of changes. The remedy was employed in twenty-five cases by himself, and in six cases by Doctor Urbantschitsch. More or less improvement occurred in nineteen cases; among these were three in which the tinnitus disappeared entirely from one ear, and in another case was somewhat diminished. From one to five drops of the remedy were inhaled at a sitting. The inhalation was continued during the appearance of the usual symptoms—flushing of the face, injection of the blood vessels of the eye, etc.,

* On the use of the nitrite of amyl in diseases of the ear. Translated by C. J. Blake, M. D., Arch. Ophth. and Otol., New York, 1878.

and suspended on the occurrence of vertigo. In all, the cases improved; the tinnitus was increased *during* the period of inhalation.

I have employed this agent in various forms of tinnitus aurium in a large number of cases; some were benefitted, but the majority were not improved, this being in part due, I think, to the impurity of the agent employed.

MIXED NARCOSIS.

"During the past two or three weeks," says the *Lancet*, December 1, "a novel mode of producing anæsthesia, called mixed narcosis (*gemischte narkose*), has been employed by Thiersch of Leipzig, whereby insensibility to pain may be procured without the total abolition of consciousness. The credit of the discovery is ascribed to Prof. Nussbaum of Munich. Although suitable for all kinds of operations, it is especially serviceable for operations about the mouth and jaws, in which blood is apt to flow into the trachea, or down the œsophagus into the stomach, and subsequently to cause vomiting. In some cases of the removal of the upper jaw lately performed by Thiersch, the patient allowed the blood to accumulate for a while at the back of the pharynx, and then spat it completely out when asked to do so; and we are informed that in one instance the patient watched with evident interest, the motion of the saw that was dividing his upper jaw-bone.

"A subcutaneous injection of morphia, from a quarter to half a grain, is given as soon as the patient is placed upon the operating table, and immediately afterward the administration of chloroform is commenced. After inhalation for about five minutes the operation may usually be begun, but the chloroform must be renewed at intervals. The patients loose all sensibility to pain, but evidently retain a considerable degree of consciousness and control of voluntary movements. Within the last month mixed narcosis has been employed five times successfully, as far as the annihilation of pain is concerned, and without any bad effects."

The dose of morphia which is given in the communication in the *Lancet* is too large for safety, as there are many persons on whom even one-quarter of a grain of morphia hypodermically will act as a powerful poison, while half a

grain even produces death. The injection of morphia should be small, say from one-eighth to one-quarter, and this should be given, according to Claude Bernard, from forty minutes to one hour before the chloroform is employed. The question should always be put to the patient, Have you ever employed morphia, and if so, what effect has it upon you? The great advantage claimed for this method is that the stage of excitement is rendered always *nil*, and less chloroform is needed to induce sleep than under ordinary circumstances. It must always be borne in mind that nausea and vomiting are not uncommon at the commencement if the morphia is quickly absorbed. This, with the vomiting which accompanies chloroform, will, we fear, be apt to complicate a delicate operation, and then you have the double risk of two such poisonous agents.

CHLOROFORM IN THERAPEUTICS.

Internal use in Substance or Vapor.—Chloroform is used in medicine both for its stimulant and narcotic properties, to increase force, subdue spasm, and relieve suffering. Given in large doses it abolishes pain and contraction, paralyzes muscle and nerve, profoundly depresses force, and leads to death. The largest amount of chloroform inhaled by one person was one hundred and twelve and a half drachms in one day; another took one pound in five days; recovery has occurred after the swallowing of two ounces of chloroform.

After the continuance of the habit of chloroform-taking the following symptoms generally appear, in the following order: (1) sleeplessness of a most distressing character, and only to be overcome by abstinence from chloroform; (2) deafness; (3) apathy and disinclination to society and to conversation; (4) tremulousness of the hands.

Experience shows that frequent chloroform inhalation is like "dram-drinking." Its effects are similar to those of alcoholism, and it will produce symptoms resembling mania-â-potu. In the report of the committee of the Medical and Chirurgical Society of London, it is stated that a man who had been accustomed to the use of enormous doses of chloroform to relieve asthma, frequently inhaling forty drachms a day, was reported to have had this appearance

"on his admission to the hospital; he seemed in a constant *state of dullness*, or like a person *intoxicated*."

Chloroform, by its wonderful power over pain and muscular spasm, has been employed in cases of poisoning by strychnia, with decided success; even should it, as was proved, have no antidotal action, it is of great service in relieving the fearful suffering, reducing the pulse to its natural standard, and causing respiration to become more easy. Another important matter is that, under chloroform or ether anæsthesia, the tetanic convulsions from the strychnia are so controlled that nutritive enemata may be administered and retained.

Chloroform is valuable in the treatment of acute mania, chorea, and convulsions, especially in children, also in puerperal convulsions; it has proved to be an efficient remedy in our hands in procuring sleep. In cases of delirium tremens, in the reduction of hernia, and the diagnosis of abdominal tumors, chloroform will be found most valuable.

The late Dr. Snow relates an interesting case of a scientific man who became insane and refused to take food. It was found that if chloroform were given, and food offered during the wakeful stage, the patient would take it; chloroform was, therefore, administered before every meal for a long period. It has also been employed in the delirium of fever in cases where the patient has been worn out, in spasmodic diseases of the air passages, spasm of the glottis, laryngeal cough, spasmodic croup, and whooping-cough when in very dilute vapor.

Dr. Sansom has found great value from the use of chloroform in several cases of phthisis. The same authority states that in some cases of chronic bronchitis, in acute bronchitis, and in pneumonia, when danger may occur from stasis of blood in the lungs themselves, it is not advisable to employ chloroform by inhalation. In paroxysmal and violent cough (combined with morphia, glycerine, and water) it is often very beneficial; and in the early part of the treatment of asthma, thirty to fifty drops inhaled from a handkerchief relieve the spasm, induce narcosis, and prevent the paroxysms.

Dr. Hyde Salter, the great authority in the treatment of

spasmodic asthma, says: "The inhalation of chloroform is, beyond doubt, one of the most powerful methods of treatment of the asthmatic paroxysm that we possess." Properly diluted, the vapor is not pungent; and instead of increasing any tendency to spasm, at once relaxes it. Dr Salter has never seen any bad effects from chloroform administered in the height of a paroxysm of asthma, and persons sound asleep may be chloroformed without their being awakened. Anæsthesia cannot, however, be produced in any one partially awake, or even lightly sleeping, without their knowledge.

One of the secondary effects of the prolonged use of chloroform in asthma is an increase of the asthmatic tendency. The use of chloroform must no more be allowed to become a habit than the use of opium. We have repeated this experiment in seven cases of asthma, and, although we felt some apprehension, still no disagreeable symptoms presented themselves, and the patient was relieved of the attack; but it returned, and, fearing its injurious influence, we substituted hydrate of chloral during the paroxysms, especially when sleeplessness occurred. Patients vary in the benefit which they derive from chloroform; in some, small quantities not only relieve the urgent distress, but also prevent its recurrence. The congestive chills of the South, or the cold stage of intermittent fever, may be shortened, so as to gain time for the introduction of quinine into the system, by the inhalation of chloroform. Dose, twenty drops, sprinkled on a fine net, permeable to the air, and repeated several times until the effect required is produced.

In epilepsy, the inhalation of chloroform has been found valuable, especially in the treatment of injuries and fractures, the result of epileptic attacks. It will also be found useful internally in the same disease, in combination with the bromides of potassium, sodium, calcium, and iron, with or without strychnia.

In neuralgia, a few inspirations of chloroform-vapor from a towel or handkerchief (sometimes enveloped in a cone of paper, flannel, or metal, for convenience of administration and to regulate evaporation) will often relieve the severe pain, almost magically. If the suffering be not of a serious character, and the affection be moderate in its extent, the

relief may be permanent. If the stimulant effect should be desired over a larger portion of the body, the following liniment can be employed with advantage:—

℞.	Chloroformi,	f℥jss.
	Pulveris camphoræ,	℥j.
	Spiritus terebinthinæ,	f℥ss.
	Olei lavandulæ,	♏xx.
	Olei olivæ,	f℥ij.—M.

The camphor to be broken in small pieces, and dissolved in the chloroform and turpentine; the olive oil should then be warmed, and added gradually. Ointment for topical use in neuralgia: in the proportion of from five to fifteen of chloroform to thirty parts lard. By means of a speculum, the vapor of chloroform may also be carried into the vagina or rectum, remaining for ten minutes; or we may use a mixture of equal parts of the chloroform liniment, of the Pharmacopœia, and the officinal camphorated soap liniment, for the same purpose.

Chloroform has been found extremely valuable in all cases of *colic*, and will often assuage even pain of *colica pictonum;* this is due to its local anodyne and stimulant carminative action. In flatulent distension of the stomach equal parts of chloroform and camphor will be found beneficial. In diarrhœa, after the removal of the irritating agent, equal parts of chloroform and alcohol, with a portion of the tincture of opium and capsicum, may be administered with great benefit. In insomnia, where pain prevents the patient from sleeping, the following mixture will often prove useful:—

℞.	Morphiæ muriatis,	gr. iss.
	Alcoholis,	
	Chloroformi,	āā f℥ss.
	Tr. cardamomi comp.	f℥jss.—M.

Sig. A dessertspoonful at bedtime to be taken in milk.

In nervous headache the accompanying prescription will often produce a happy effect:—

℞.	Acidi nitro-muriatici diluti,	f℥ij.
	Strychniæ,	gr. 1/4—1/2.
	Alcoholis,	
	Chloroformi,	āā f℥iij.
	Tinct. zingiberis,	f℥iij.
	Aquæ,	q. s. ad ft. f℥iii.—M.

Sig. A teaspoonful in water three times daily.

In combination with quinia, chloroform may be given where there is marked tendency to frequent chills. The following formula would be very appropriate for malarial manifestation in a child, say three or four years of age:—

℞.	Quiniæ sulph.,	gr. xxiv.
	Mucilago acaciæ,	f℥ij.
	Chloroformi,	♏xx.
	Syr. Tolutani,	f℥iv.
	Aq. cinnamonii,	q. s. ad f℥iij.—M.

Sig. A teaspoonful every hour while free from fever.

In certain forms of chorea and epilepsy, the combination of bromide of potassium and chloroform will be found valuable:—

℞.	Potassii bromidi,	gr. xv.
	Tinct. conii,	♏xxx.
	Chloroformi,	♏xx.
	Tinct. valerianæ ammoniatis,	♏x.
	Aquæ camphoræ,	f℥j.

Sig. For one dose, to be repeated every six or twelve hours.

In some cases advantage is obtained by adding strychnia to this mixture in the dose of one-sixtieth to one-thirtieth of a grain, omitting the conium and the valerian.

The following are a few of the preparations of chloroform:

1. Tinctura chloroformi comp., B. P. (chloroform, rectified spirits, comp. tinct. of cardamon; one in ten). Dose, ♏xx–lx; for internal use, to relieve pain and spasm.

2. Linimentum chloroformi (chloroform ℥ij, camphor liniment ℥ij, olive oil ℥iv).

3. Mistura chloroformi (chloroform ℥ss, camphor pulv. gr. ix, yolk of one egg, water ℥vi). Add chloroform and camphor, rubbing them up well; then add the egg by degrees to form a nice mixture. Dose, a tablespoonful every hour.

External use.—Powerful agents act on the skin more effectually when dissolved in chloroform, as they promote the cutaneous absorption, and the addition of an equal quantity of alcohol hastens the process; so that when we desire to limit the anodyne effect to a small spot, we may apply a solution of camphor in chloroform, of equal parts by weight, or as a still more powerful sedative:—

℞. Morphiæ sulphatis, gr. viij.
Atropiæ sulphatis, gr. iv.
Alcoholis,
Chloroformi, āā ℥ij.—M.

Sig. To be applied with a camel's hair brush.

Two other agents might be added for facial and dental neuralgia: Ext. gelseminum* fld., gtt. iij every three or four hours; or, butyl-chloral hydrate in pills, three grs. every three or four hours.

This prescription, in facial or sub-occipital neuralgia, should not be spread over a large surface at one time, as both the atropia and the morphia are more readily absorbed after this solution in chloroform. Strychnia, aconitia, or quinia may also be combined with chloroform in a similar manner. A very good plan is to cover a cup with linen and drop a portion of the chloroform or the mixture on its surface, and hold it in contact with the painful part for a few seconds. This will often produce a good result in pleurodynia or neuralgia of the chest wall. In more severe general neuralgia, I have on several occasions been obliged to keep the patient gently under the influence of chloroform for a considerable time until the person obtains sleep, or the pain has been entirely relieved. If the neuralgia, in the form of hemicrania or sciatica, should be of malarial origin, we may resort at first to the following mixture:—

℞. Veratriæ, gr. v.
Morphiæ sulphatis, gr. iij.
Linimenti chloroformi, f℥ij.—M.

Fiat lotio.

The part to be rubbed with this lotion during the paroxysm of pain, while two-grain pills of quinia sulphas are given every hour until its physiological effects are produced. Cinchonidia may be substituted in three-grain doses if the patient cannot take the quinia.

This same treatment, in conjunction with quinine, will often relieve sciatica. In earache or toothache, two or three drops on a small piece of cotton-wool introduced into the ear or tooth will occasionally cause complete relief; if too large a quantity is used, it will cause redness, smarting, and

* The effects of this remedy should be carefully watched.

even blister. Equal parts of chloroform and opium or creosote are also useful in toothache. When mixed with an equal quantity of camphor, it forms one of the most valuable agents to relieve the local pain of sprains, etc. In cancer, where the skin is broken, leaving a foul and irritable sore, the surface may be deodorized and the pain temporarily relieved by the use of the hand-spray playing the vapor on the raw surface. The pain of other forms of cancer, such as of the os uteri, rectum, and mammary gland, may be also relieved by application of the same agent. In the photophobia of scrofulous ophthalmia, a few drops of chloroform held in the palm of the hand, close to the irritable eye, will cause the child to bear the light with less pain. In the itching of the ear, nose, and rectum, in which we have urticaria, lichen, or prurigo, the annoyance may be allayed by the use of an ointment composed of half a drachm of chloroform to an ounce of lard (it must be kept in a ground-stoppered bottle).

Pruritus Vulvæ.—In this most persistent, troublesome, and annoying disease, we have found chloroform useful in combination with carbolic acid and soap liniment, as follows:—

℞.	Acidi carbolici,	gtt. xii-xxiv.
	Chloroformi,	f℥ij.
	Ol. olivæ,	
	Linimenti saponis,	āā f℥ij.—M.

Apply with a soft sponge to the affected parts.

Chloroform dissolves entirely in vaseline, and furnishes a homogeneous product of convenient consistency without the addition of wax:—

℞.	Chloroform,	iv grammes.
	Vaseline,	xx "

Equal parts of vaseline, chloroform, and ether, give a jelly, which constitutes one of the most active liniments in English therapeutics.

Both of the above preparations are useful in neuralgias, cancer of the rectum and uterus, and are increased in value by the addition of hydrate of chloral, five grammes, or camphor, three grammes. This latter agent has to be pulverized and added to the vaseline, heat being applied until the camphor completely disappears, and stirring until cold.

In urticaria, lichen, eczema, and true prurigo, the following ointment will not only allay the itching effectively, but with care will cure these skin affections.

℞.	Hydrg. præcip. alb.	ʒss.
	Liq. carbonis deterg.	♏xx.
	Chloroformi,	ʒss.
	Vaseline,	℥i.—M.

Sig. Apply locally.

CHLORODYNE.

ANODYNE, SEDATIVE, ANTI-SPASMODIC, AND DIAPHORETIC.

This preparation produces anodyne, sedative, anti-spasmodic, and diaphoretic effects of other opiates, without giving rise to the nausea, prostration, loss of appetite, and depression of spirits, which are so apt to follow the use of the latter, and are sometimes so distressing as to preclude the employment of such articles where they would otherwise be strongly indicated. It must, however, be prescribed with the greatest caution, and never unless the particular preparation is specifically stated.

℞.	Morph. sulph.	grs. lxiv.
	Alcohol, ninety-five per cent.	fʒxii.
	Chloroform purif.	f℥vi.
	Acid. sulph. Ar.	qs.
	Ext. cannab. Indica (Allen's),	ʒss.
	Oleoresina capsicum,	gtt. xij.
	Hydrocyanic acid (Scheele's),	gtt. xcvi.—M.

Shake together the morph., alcohol, and chloroform, then add acid sulph. q. s.; shake well until it becomes clear, then add capsicum, ext. cannab. Ind. and hydrocyanic acid. The dose for children, of from five to ten years, is from five to eight drops in water, repeated every three hours; dose for adult, fifteen to thirty drops. Each teaspoonful contains one gr. morph. sulph., one-half gr. Indian hemp, one and a half drops of Scheele's acid, equal to nearly four drops of U. S. P. acid.

The importance of not trusting to the patient's judgment is very necessary, and the quantity which is to be taken in the twenty-four hours *must* be stated, and the intervals between each dose, carefully given. From 1863 to 1867, four deaths were caused by this compound. According to Mr. G. Smith,* the English preparation is thus constituted:—

* London Lancet, 1870, vol. i. p. 72.

℞.	Chloroform,	℥iv.
	Muriate of morphia,	gr. xx.
	Ether (rectified),	f℥ij.
	Oil of peppermint,	♏viii.
	Prussic acid,	ℨvi.
	Mixture of gum arabic,	℥i.
	Treacle,	℥iv.—M.

It will be noticed that there is no uniformity in this compound, which should not be the case, and pharmaceutists should adhere to either one or the other of these formulas, and not add to or take from them, marking the one the English, and the other the American preparation, and its manufacturer.

EARACHE.—CHLOROFORM VAPOR.

National Medical Review, February, 1879.—Dr. James E. Morgan stated, during a discussion on otitis, that he had often promptly relieved the distressing earache of children by filling the bowl of a common new clay pipe with cotton wool, upon which he dropped a few drops of chloroform, and inserting the stem carefully into the external canal, and adjusting his lips over the bowl, blew through the pipe, forcing the chloroform vapor upon the membrana tympani. Dr. J. Ford Thompson had also accomplished the same relief upon similar principles. This same result we have often attained by means of cotton saturated with chloroform in a glass tube, or surrounding the cotton with a second layer so as not to come in contact with the surface of the meatus.

CHLOROFORM DURING DELIVERY.

Dr. Wilson, of Baltimore, dissents from the views of Dr. Lusk as to the danger of using chloroform in obstetric cases. See p. 107.

Dr. Albert H. Smith, of Philadelphia, thinks that chloroform is to be preferred to ether in those cases in which a rapid anæsthesia is desired.

Dr. Ringer* gives it as his opinion, "that it is not necessary to obtain complete unconsciousness, but to give only sufficient chloroform to dull the pains. If this recommend-

* See article Chloroform, Opt. Cit., p. 312; Chloral, p. 357.

ation is disregarded, and the anæsthetic is pushed to the stage of complete unconsciousness, it weakens the contraction of the womb and retards delivery. It is true that even if only slight unconsciousness is produced, the uterine contractions are probably somewhat weakened."

Dr. Playfair thinks that chloral acts far better than chloroform inhalation, as chloral does not lessen the strength of the contraction, whilst it greatly lessons the suffering. Moreover, it is chiefly applicable at a period when chloroform cannot be used—that is, towards the termination of the first stage. Dr. Playfair gives fifteen grains, and repeats the dose in about twenty minutes, and again repeats the dose, if necessary.

The following communication was received too late to be inserted under Ether.

Dr. E. L. Holmes has observed threc cascs, in which severe *neuralgia* was experienced immediately on recovering consciousness, *after full anæsthesia from ether*. In the case of a young woman to whom ether was given for a strabismus operation, the neuralgia, with some numbness and paralysis of motion in the outer portion of the left fore arm and fingers, was extremc; this continued three months, when the paticnt passed from observation. In a second case, a woman of middle age, thc neuralgia in thc left arm and shoulder continued more than three months before it ceased. In the case of the third patient, also a woman, the neuralgia was quite severe for some weeks in the shoulder and neck.

The late Dr. E. H. Clarke, of Boston, a few years since stated to the wrlter that he had observed several similar cases.

CHAPTER V.

Mixtures of Chloroform, Ether, and Alcohol. First death reported from mixture of Ether and Chloroform. Composition of various mixtures. Boiling points and relative time of evaporation of the several anæsthetic agents. Opinions of Dr. Washington Atlee and Prof. Maisch concerning mixtures. How Chloroform is altered by mixing with Alcohol, etc. Recent deaths from Chloroform and Ether mixed. Chloroform combined with Alcohol in parturition. The comparative effects of the early state of anæsthesia with Ether and Chloroform.

THE various mixtures of chloroform with ether and alcohol, were used as means of escaping the danger of chloroform. They first received their impulse from the report of the Chloroform Committee of the Medical Chirurgical Society of London, who declared their superiority in point of safety. M. Perrin* gives an account of the first death known at that time to have taken place under a given mixture of ether and chloroform, and gives the credit to the chloroform as being improperly administered, and Snow says the patient died of hemorrhage; but our reading of the case, carefully reported by Dr. R. Crockett,† leaves the decided impression that chloroform arrested the heart's action, induced vomiting, and caused a stoppage of respiration. The following is an abstract of the important facts in the case, and is interesting as the first death from the mixture:—"A sprightly little boy, five years of age, was brought to the doctor to have a fatty tumor removed from his back. The tumor commencing at a point at its inferior termination, opposite the last rib, about two and a half inches to the right of the spinous processes, and extending obliquely upwards, crossing the spine

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* Traité d' Anesthésia Chirurgicale, Par Maurice Perrin, Professeur agrégé a l'Ecole Impériale de Médicine et de Pharmacie Militaire, etc. A Ludger Lallemand, Professeur agrégé à l'Ecole Imperiale de Médicine et de Pharmacié Militaries, etc. Paris, 1863, 8vo., pp. 668.

† American Journal of Medical Sciences, July, 1857, 284-5.

seven inches, requiring two elliptical incisions nine inches long for its removal." The operation was commenced at 9.30 A. M., April 4th, and the dissection was rapidly executed, stopping to ligate a large artery that was early divided; the remaining arteries were compressed as they were divided. The tumor was quickly removed, and a ligature applied to the last artery, being the sixth in number. While sponging the wound, the boy began to vomit, and on examining the wrist he was found to be pulseless. Dr. K., who had charge of the anæsthetic and pulse, replied that "the pulse had never given way until he began to vomit." He ejected a small portion of the contents of the stomach. He was immediately placed in the "prone position," as recommended by Dr. Marshall Hall; the finger was introduced into the mouth to be certain that the tongue had not fallen back so as to obstruct the glottis, or the entrance of air into the wind-pipe, and the extremities were rubbed with aqua ammonia. The patient died three or four minutes from the commencement of the vomiting. "He lost probably four ounces of blood, certainly not exceeding six." There was no *post mortem* examination.

The anæsthetic we used was a mixture of washed ether, four parts, and one of chloroform, obtained from the late Frederick Brown of Philadelphia, whose character is a sufficient guarantee that they were pure. Every preparation for the operation having been made, the administration of the anæsthetic was commenced by Dr. Crockett, observing all the precautions so fully recommended by Erichsen, p. 78, of his "Operative Surgery." As soon as anæsthesia was induced, the sponge was confided to Dr. Kincannon, who held his finger all the while on the patient's pulse. The doctor concludes, "I have lately employed this anæsthetic freely, formerly having used ether alone. *As yet I have not seen a case of death reported from ether*, or this mixture of it with chloroform, that I can now recollect. Are there any such reported? I fear all the deaths from anæsthesia are not reported." Five deaths from the use of this mixture have been published, two having occurred very recently.

The chief object of these anæsthetic mixtures is the avoidance of the danger from *shock*, or from the depressing

influence upon the heart-action, which chloroform most certainly exerts, and which ether and alcohol prevent. The committee before referred to proposed the following mixtures:—

A.	Alcohol, ...	1 Part.
	Chloroform, ...	2 "
	Ether, ...	3 "
B.	Chloroform, ...	1 "
	Ether, ...	4 "
C.	Chloroform, ...	1 "
	Ether, ...	2 "

Dr. Samson's mixture* is equal parts by measure of chloroform and absolute alcohol. The introduction of alcohol, which plays an important part in the mixture, was, according to the doctor, due to Dr. Harley. The committee says it is by "the uniform blending of the ether and chloroform, when combined with alcohol, and probably the more equable escape of the constituents in vapor." The chloroform is the potent agent, and the others chiefly adjuvants, vehicles, and diluents of the chloroform.

Dr. Sansom gives the following testimony as to the stimulating effects of alcohol in counteracting the depressing influence of chloroform. In my own experiments I have found that alcohol has had the greatest effect in sustaining the heart action during the influence of the chloroform. I can particularly recollect one instance in which alcohol was administered in vapor to a frog, after it was impossible to cause death by any strength of chloroform vapor. In recommending this mixture before the Obstetrical Society of London, Dr. Sansom went one step farther, and stated that this mixture gives off a proportion of chloroform vapor in a given time almost exactly half of that which is given off by chloroform pure and simple. This result is not confirmed by any experiments of his published.

What are the objections to anæsthetic mixtures?

1. The length of time required for the production of complete anæsthesia. 2. The probability of entire sensibility not being abolished. 3. The unequal rate of evaporation or vaporization of the fluids.

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* Chloroform: its Action and Administration. By Arthur Sansom, M. B., London.

There is not any doubt but that the process is slower and attended with more excitement by the mixed fluids than by chloroform alone. The second objection cannot be sustained. The third is the "element of danger." It was first advanced by Snow. He says: "When ether is combined with chloroform, the result is a combination of the undesirable qualities of both agents without any compensating advantage," and the danger is because the operator, toward the end of the process, may be giving a pure chloroform when he thinks he is giving the weaker mixture of vapors. Dr. Ellis* endeavored to prove this, and states: "Out of the six or seven minutes occupied by the evaporation of the half drachm of fluid, the first was occupied chiefly by the ether, the next three by the chloroform with a little alcohol, and the last by the alcohol alone. In an inhaler the patient would have breathed, for one-fifth of the time, chiefly the vapor of ether, for the next three-fifths that of chloroform with a little alcohol, and at last only the vapor of a minute quantity of alcohol," pp. 24, 25. These results are not stated as obtained by actual experiments, and they depend, first upon the purity of the agents employed; second, upon the boiling point, which has a great influence upon the results, for the more volatile the fluid, the greater will be the variation. I here give the boiling point of the most important anæsthetics.

The temperature which is constant for the same substance, under the same atmospheric pressure, is called the *boiling point.*

The following are the agents employed as anæsthetics in the form of vapor, the boiling points being given for the mean pressure of 760 millimetres:

Protoxide of nitrogen,	—88°
Carbonic acid,	—78°
Chloride of Ethyl v. pure ether,	11°
Common ether,	35°
Chloroform,	63°
Alcohol,	78°
Oil of turpentine,	157°

A difference of pressure of 0.25 centimeter will cause a dif-

* On the Safe Abolition of Pain in Labor and Surgical Operations, 1866, by Anæsthesia and Mixed Vapors. By Robert Ellis, Surgeon Accoucheur, London. 1866, pp. 80.

ference in the boiling of water one-tenth of a degree. The boiling point is also influenced by dissolving in a fluid a substance more volatile than itself (as ether and chloroform); it increases the boiling point in proportion to the amount dissolved. The temperature of the atmosphere has a powerful influence on these volatile agents, as it is a well-known chemical fact that the saturability of the air increases vastly with the increase of temperature, and the capacity of the air for aqueous vapor is doubled with each 27° of temperature Fahrenheit. Sulphuric ether at 60° F., and thirty inches of the barometer expands two parts of the air into three, and forms, therefore, at that temperature and pressure, one-third of the air inhaled into the lungs of a patient. Under the same circumstances chlorform expands fourteen parts of air into fifteen, and consequently the vapor of chloroform constitutes one-fifteenth part of the air inhaled.

The following experiments were made October 30th, 1878, so as to determine the time required for each of the agents to evaporate on a given surface of tissue paper suspended in the air at a temperature of 70° F., one drop of each being carefully measured by the same dropping machine. The time was accurately kept by my son, Dr. C. S. Turnbull, and the results served to confirm the rough experiments made before the Dental Convention at Washington, D. C., on October 10th, 1878, and proved the facts stated in the author's first edition of this work. I have always found that when such a mixture was poured upon the inhaler, the most volatile spirit will arise first, then the next, and so on, leaving the least easily evaporated upon the inhaler. Another important fact was proven, and which was before referred to, that the alcohol employed in the mixtures with chloroform in England, also the ethers made from such alcohols, are much inferior to those made in this country from grain, not from wood or potatoes. These latter are slow in evaporation, and are mixtures themselves containing a large amount of carbonaceous products.

The following are the results obtained after numerous experiments with as many of the agents employed in the various mixtures, and obtained from the reliable establishments of Powers & Weightman, Bullock & Crenshaw, Wyeth & Bro., and J. P. Remington:

Alcohol, absolute, 95° (W. & Bro.), ...	1 min.	24	seconds.
Alcohol, common, (W. & Bro.), ...	10 "	00	"
Chloroform (P. & W.), ...	00 "	24	"
Ether (Squibb's), ...	00 "	12	"
Ether, common, 0.750 (P. &. W), ...	00 "	24	"
Ether Hydrobromic (R), ...	00 "	12	"
Methylic alcohol (B. & C.), ...	1 "	00	"
*Potato spirit (B. & C.), ...	12 "	00	"

Temperature, 70° F.
Barometer, 30.08. Time, 2 P. M.

Besides the danger from inhaling the chloroform pure and simple, there is another to be prevented, that is, to get rid of the watery vapor, from the mixture and also from the lungs of the patient, which collects on the sponge. If the napkin or inhaler gets close to the patient's mouth and nose it will most effectually prevent air from reaching the lungs. How is this to be prevented? By squeezing out the sponge, napkin, lint, or if an inhaler is employed that cannot thus be treated, casting it aside, and taking a clean napkin, with as much starch in it as possible, so as to keep it in shape. It may again be inquired which is the best mixture to employ in ordinary surgical operations when it is absolutely necessary to employ such mixtures. The mixture C, in midwifery. Mixture A, or, as it is familiarly known, A C E or "ace of spades mixture," the most agreeable of all. In the operation for ovariotomy I prefer the C mixture, as also advised by the late Dr. Washington Atlee; the volume of the two agents are so different that they ought to be mixed by weight, not by measure, else the chloroform will be much in excess, as it is a little over twice the weight of ether. In employing alcohol it should be as near to absolute as possible, and free from color, smell or taste. The ether should be almost anhydrous, pure, full strength, and well washed.

Dr. Atlee was of the opinion that there is a chemical union of the ether and chloroform; and Professor Maisch, of this city, found that, if this mixture was exposed to the light, a change took place which rendered the mixture not fit for the purposes of inhalation; it therefore should be kept from the light, and mixed just before being employed.

Perfectly dry chloroform decomposes but slowly, even in direct sunlight, but the presence of water, which always

* Passed through charcoal by W. & Bro.

exists in alcohol and ether, and the action of light at the same time causes chloroform to decompose into formic and hydrochloric acids. $CHCl_3+2H_2O=CH_2O_2+3\ HCL$.

I have had charge of the anæsthetic mixture (one part by measure of chloroform, and two of washed sulphuric ether) in an operation by Dr. Washington L. Atlee, during the successful removal of on ovarian tumor weighing forty pounds, and have also assisted him in three cases in which others gave this same mixture, with good results, and with no apparent risk to the safety of the patients.

Dr. Atlee always administers the anæsthetic after the patient is upon the operating table, and one individual has charge of and is responsible for it. In his three hundred ovariotomies he informed me he had never lost a patient by the anæsthetic.

The mixture is given in almost every instance by means of the starched towel.

At my suggestion, Dr. Greene made the following experiments, to determine the best proportion in which ether and chloroform could be mixed: When ether and chloroform are mixed there is an elevation of temperature, and the greatest heat is produced when the mixture is made in equivalent proportions; that is, by weight, about nine and one-quarter parts of ether to thirteen and one-quarter parts of chloroform. As the chloroform is more than twice as heavy as ether, the volumes would be about one and four-tenths chloroform to two of ether. But little contraction in volume takes place, and it may be considered that molecular combination takes place between the chloroform and ether. The mixture begins to boil at fifty to fifty-one degrees C., and may be separated into its constituents by fractional distillation; but when allowed to evaporate spontaneously, as when used as an anæsthetic, both liquids pass into vapor simultaneously.

Whatever mixture is employed, nothing will obviate the necessity of care in the administration, and above all not to give more of the agent than is absolutely necessary to keep the patient free from pain; not one drop more, for, like all potent medicines which we employ, an excessive dose is sure to kill, and unless we have before gauged the patient's powers, let caution be our guide

in the administration of so powerful an anæsthetic. In our anxiety to see the various steps of an operation, we must not saturate the sponge or lean over the patient, and by accident suffocate him. It is, unfortunately, too much the practice to entrust the inhaling apparatus to some inexperienced hand, who, perhaps, never before administered an anæsthetic, and even in some hospitals to the youngest assistant surgeon or dresser. It has been well observed by Perrin: "We believe we shall render a veritable service if we popularize the idea that anæsthesia should be observed and studied at the hospital with as much care as every other subject of practical medicine." Sansom also says, "The administrator should be experienced; several hospital committees have acted wisely in appointing a chloroformist, a measure which is not of less value to the operating surgeon than it is to the benefit of the patient. One who administers chloroform in any case should confine himself exclusively to the task he has undertaken, and should constantly mark the symptoms." What are the symptoms of danger? The failure of the pulse, irregularity of the respiration, and the blanched countenance, and, as beautifully expressed by an old writer* in reference to successful administration of anæsthetics, "Proceed steadily but cautiously to the end in view. He makes haste slowly, and with a boldness tempered by wisdom, carries his patient down into the dark valley which borders on death, drowns human agonies in the water of Lethe, and triumphs in the crowning glory of his art."

AN ABSTRACT OF THE REPORTS OF RECENT DEATHS FROM A MIXTURE OF ETHER AND CHLOROFORM.

The mortality caused by a mixture of chloroform and ether given by inhalations is 2 to 11.176, or 1 to 5.588.

A death of a lady had occurred in the practice of Dr. Eastham, a dentist of Boston, causing much excitement in professional circles. The death had taken place about noon, but very few, except those particularly interested, were

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* I. C. R. Am. Jour. Med. Sci. 1867, p. 190.

aware of it till the next day. The coroner, Dr. Ainsworth, who was called in directly after the accident, formed a jury of physicians and apothecaries, and ordered an autopsy. This was made the next morning by Dr. R. H. Fitz, pathologist to the Massachusetts General Hospital; and on the same day the jury met, and, having viewed the body, adjourned until the 14th. The anæsthetic was either chloroform or a mixture of chloroform and ether. The latter proved to be the one used. The jury met again on the 14th, and, having heard a part of the evidence, readjourned till the evening of Wednesday the 19th. Instead of death resulting from ether, it was, as proven by analysis, due to *chloroform*, and the coroner's jury presented the following verdict:—"Death was caused by the inhalation of chloroform, administered in a mixture of chloroform and ether."

Dr. Henry Buren, of Chicago,* gives the following version of a death which took place in that city from the inhalation of a mixture of ether and chloroform:—

Mrs. B., aged 32, American, had suffered from fistulæ in ano for six months. On the 22d of November last, I operated on her, finding at this time two artificial openings into the rectum, one on either side of the anus. Dr. A. Groesbeck administered the anæsthetic, which consisted of equal parts of sulphuric ether and chloroform. The operation was performed in a few seconds. The patient exhibited no alarming symptoms while under the influence of the anæsthetic, and revived in the usual time.

On the morning of the 30th of November, eight days after the operation, I desired to make a thorough examination of the wounds and renew the dressing, and in this, as in some of the previous dressings, the patient insisted upon partial immunity from pain. To this end I commenced to administer upon a napkin two parts of sulphuric ether and one of chloroform. After a few inhalations the patient became violently intoxicated, and resisted, with great force, all efforts to quiet her, demanding in the language of one in delirium, to be let alone. I immediately ceased to administer the anæsthetic, and with great effort prevented her from jumping from the bed. The face became at first turgid, the

* Chicago Medical Journal, February, 1878.

whole body convulsive, and in a few seconds the patient was dead.

All of the means usually resorted to, were employed to restore aetion of the vital functions; artificial respiration, elevating the lower extremities, dashing cold water in the faee, drawing forward the tongue, spirits of ammonia applied to the nostrils, and, finally, a galvanic battery, which was conveniently at hand, but to no avail.

I have to say in justice to the record of this ease, that the patient had for many years habitually partaken of opium. At the time of her unfortunate death, she eould take at eaeh dose, from two to three grains of morphia. During the time she was under my care, one half grain doses of morphia were prescribed at proper intervals, but she asserted that this quantity did not sufficiently support her, and through her nurse, and by stealth, she secured additional quantities from the neighboring drug stores, and took the same daily without my knowledge or consent.

I am now of the opinion that the patient had taken an unusually large dose of morphia on the morning of her death, and that the combined influence of this overdose, and the additional paralyzing effects of the anæsthetie, caused cardiac syncope, and that this was the eause of death.

A woman aged forty-six, extremely fat, and of slow intelligence, although having complained of shortness of breath, was not known to be the subjeet of organic heart disease. She was to be operated upon for senile cataract. A mixture of chloroform and ether, in a modified Clover's apparatus, was being administered by the house surgeon. From the commencement of the administration, respiration was noticed to be shallow, but there was struggling. The pulse was feeble, but not intermittent. There was some slight lividity of cheeks and forehead. Chloroform was at once removed and a few whiffs of pure ether administered as a stimulant. Other means for circulation were tried, but in vain; the patient died. At the *post mortem* examination the heart was found flaccid and empty; the mitral valve was contracted; the aortie valves were incompetent; kidneys fatty and granular.—(*Med. Times and Gazette*, August 18th, 1876.)

A more recent case of *death* from a *mixture* of *ether* and *chloroform* is reported in the Philadelphia Medical Times, March 15, 1879, by I. A. Cleary, Assistant Surgeon U. S. A. Private H. D. B., Co. 19, U. S. Infantry, aged 33, large, robust, addicted to liquor. Injury of middle finger, right hand, resulting in gangrene; decided to amputate. A mixture of equal parts of ether and chloroform (*weight or measure not stated*). Two ounces whiskey were given ten minutes prior to inhalation. The anæsthetic was administered on a piece of lint covered with a small towel held square. He personally administered the mixture, while the steward observed the pulse; air was freely admitted; he inhaled freely. About two drachms were first poured on the cloth, but with no apparent effect (*he, evidently, receiving nothing but ether*). Shortly after about the same quantity was poured on; he observed that "he did not feel it." After a time about the same quantity was again poured on. A further quantity was poured on the cloth (say in all ʒviii) when he began to laugh, followed by attempts to articulate, and made strong gesticulations of his arms. He now passed to a state of unconsciousness, when the pulse was not perceived. This was followed by relaxation and death. At once the anæsthetic was removed, cold water dashed in the face. He adds, "everything I ever heard of, saw or read, appropriate for such a case was done, but to no effect." He states as the cause of death, paralysis of the heart. (I think it was syncopy from the chloroform.)

MIXTURE OF CHLOROFORM AND ALCOHOL AS AN ANÆSTHETIC IN PARTURITION.

Dr. A. H. Halberstadt, of Pottsville, Pennsylvania, read before the Medical Society of the State of Pennsylvania, in May, 1878, a paper on "Anæsthesia in Parturition," and after some general remarks on the advantages of this mixture, says:—"I would submit the following conclusions drawn from at least one thousand cases under my own observation and management:

"1st. That the parturient state is the only condition of the system during life in which anæsthetics, judiciously administered, are entirely devoid of danger.

"2d. That the physiological action of chloroform, ether,

and alcohol in a woman during labor is not identical with that in an ordinary subject in a dental chair, or upon the surgeon's table, and from the history of such administration, free from a single well-authenticated case of death, with statistics showing its superiority over venesection, opium, etc., in the desperate emergencies attending irregular labors, as eclampsia, it is fair to infer that this agent is an especial therapeutic indication for parturient women, and should be so regarded in all labors where by its use the pains of the second and third stages could be obviated, and this, too, to the ultimate benefit of the mother, and safety of the child.

"3d. That in puerperal eclampsia it is especially indicated, because of its direct, rapid, and general action, controlling nervous physiological irregularities, exciting secretion, relaxing the os and perineum, and, in short, so preparing the parts as to aid the accoucheur in his manipulations for the essential emptying of the uterus, to accomplish which, venesection, opiates, purgation, counter irritation, etc., either singly or combined, bear to anæsthetics the relation of mere fractions to a grand whole.

"4th. Its application is universal; no diseased condition of the heart or lungs at all likely to exist where pregnancy can occur, should forbid its use—for where has a *post mortem* examination revealed a dilated and weak right heart from fatty degeneration in the body of a pregnant woman *at full term?*

"5th. That in view of its known therapeutic action and safety in the small quantity required to produce narcosis, no use of the forceps, version, nor obstetric operation of any moment should be performed without it; not only to save the patient from shock and its consequences, but because of the great saving of time and labor, and, in most instances, the assistance it affords the operator.

"6th. Owing to the fact that uterine contractions are often lessened by the administration, it is always important to precede it by an oxytocic, in all labors and at any stage, when the pains are slight, so as to increase their force, and as also to guard against post partum hemorrhage—a very infrequent occurrence where such precaution is taken.

"7th. Accidents to the unemptied bladder, ruptures of

perineum, and sphincter ani may be prevented, as well as death of the child in prolapsus of the cord by the facilities afforded for rapid delivery, especially in prumpara.

"8th. That in no instance have I seen narcosis of the child attributable to the anæsthetic.

"9th. Without any special reason, excepting the common disagreeable feature of ether, and the supposed risk of chloroform, I have generally used the mixture proposed by the Medico-Chirurgical Society of London, consisting of ether three parts, chloroform two parts, and alcohol one part, being careful as to the quality of the preparation, and having them recently mixed. With this combination I have never been disappointed, or regretted its use; and, in truth, nearly all the troublesome cases I have had after the labor were those in which, for some reason, the anæsthetic was not used."

The first proposition of the doctor is not an absolute fact, as in this work there are cases reported of death from the effects of anæsthetics in the parturient state. In the second, we would state that we have seen more than one death from anæsthesia of the child. We agree in part with the doctor in his third proposition, but great care must be taken in ascertaining if there is disease of the kidneys, heart or lungs, the administration of chloroform or its mixtures in these cases being exceedingly dangerous. In the seventh proposition, we are of the opinion that the accidents enumerated are more likely to occur when the brain is not cognizant of the action of the hands of the accoucheur, or perhaps, of the destruction by the forceps of the soft parts of the mother or child.

It is well to be remembered that there is a stage in the use of one of these agents when it can be used with comparative safety, and in regard to the other we state the fact on an experience of a close and careful observer.

EARLY STAGE OF ETHERIZATION.

Early stage of anæsthesia by ether, pupils are contracted, but when there is complete anæsthesia the pupils become dilated, and the respiration is slow and deep.

A peculiar effect of etherization, which has been early noticed and published by a careful writer and experimenter

of this city, the late Doctor J. F. B. Flagg,* and which result has been confirmed by us and by others, is stated as follows:—

"There is a particular point of etherization produced by a few deep inhalations, which if improved at the moment (slight operations can be performed) will leave the patient in full possession of all his faculties with the single exception of the *sense of pain*, and particularly the consciousness of *touch* is as acute as under ordinary circumstances, if not quickened."

In our own experiments in this stage the sense of sound and vision was always very active. If, however, the patient is roused from his first anæsthetic sleep by the pain of the knife, or a sudden noise, or a rough touch, it is always found more difficult to cause such a patient to pass into a profound state of insensibility by means of the ether. Yet, if a patient will not breathe the ether properly when it is required for an operation, it will sometimes do good to prick or scratch the surface with a knife, and then insist upon the patient breathing the ether so as to get rid of the pain.

EARLY STAGE OF CHLOROFORMIZATION.

There is also a period in chloroform narcosis when all feeling of pain ceases, but consciousness is not entirely gone when incisions or sawing of bones are perceived as mere tactile impressions, for according to Schiff, the sensation of pain is conveyed to the brain through the gray matter of the spinal cord; but the tactile impression through the white matter of the posterior columns, which, being less vascular, do not so readily succumb to anæsthesia, and retain their function a little longer.

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* Ether and chloroform. By J. F. B. Flagg, M. D. Philadelphia, Lindsay & Blakiston, 1851, p. 89.

CHAPTER VI.

Nitrous oxide gas as an anæsthetic. Mode of preparation, chemical constitution, gasometer, inhaler, and mode of purifying nitrous oxide gas. The advantages of the gas being recently prepared. Class of cases for inhalation. Difficulties and dangers, with mode of treatment. Liquid nitrous oxide in cylinders. Physiological action of nitrous oxide. Experiments and observations by Doctors Evans, of Paris, M. Buisson, Doctors McQuillen, Thomas, Robert Amory, George Johnson, and the writer. Mode of action of anæsthetics by Doctors C. Binz, H. Ranke, Claude Bernard, and Committee British Medical Association. Investigations upon the protoxide of nitrogen by Doctors Jolyet and T. Blanche. The spectroscope and its relations to nitrous oxide. Experiments of Doctors Waterman, J. G. Richardson, Wm. M. Hodges, C. S. Turnbull, and the writer. Nitrous oxide gas in dental and minor surgery. M. Paul Bert on the use of a mixture of nitrous oxide and oxygen gases. Deaths from the inhalation of nitrous oxide.

NITROUS OXIDE GAS.

In entering upon the subject of nitrous oxide it is not my purpose to go into its discovery, early history, etc., as a short statement is made in another part of this work, and numerous referenees are given for those that are interested. This anæsthetic can be employed in a few operations in surgery; these are, extraction and surgical operations on the teeth and gums. With it the ophthalmic surgeon can operate for ordinary strabismus, or removal of small tumors, or even enucleate the diseased eyeball. It is very valuable in examining the urethra for stricture, and even the cutting of an impervious stricture has been performed with success. Necessary manipulation for recent luxation, in stiff joint, and tenotomy of tendons for the relief of club foot, etc., have all been performed while under its influence, and in conjunction with sulphuric ether almost all surgical operations can be performed.

My chief object will be to treat of this anæsthetic in its practical relation in connection with dentistry. I am indebted for most of my facts to Dr. J. D. Thomas, of this city, the highest American authority on this subject.

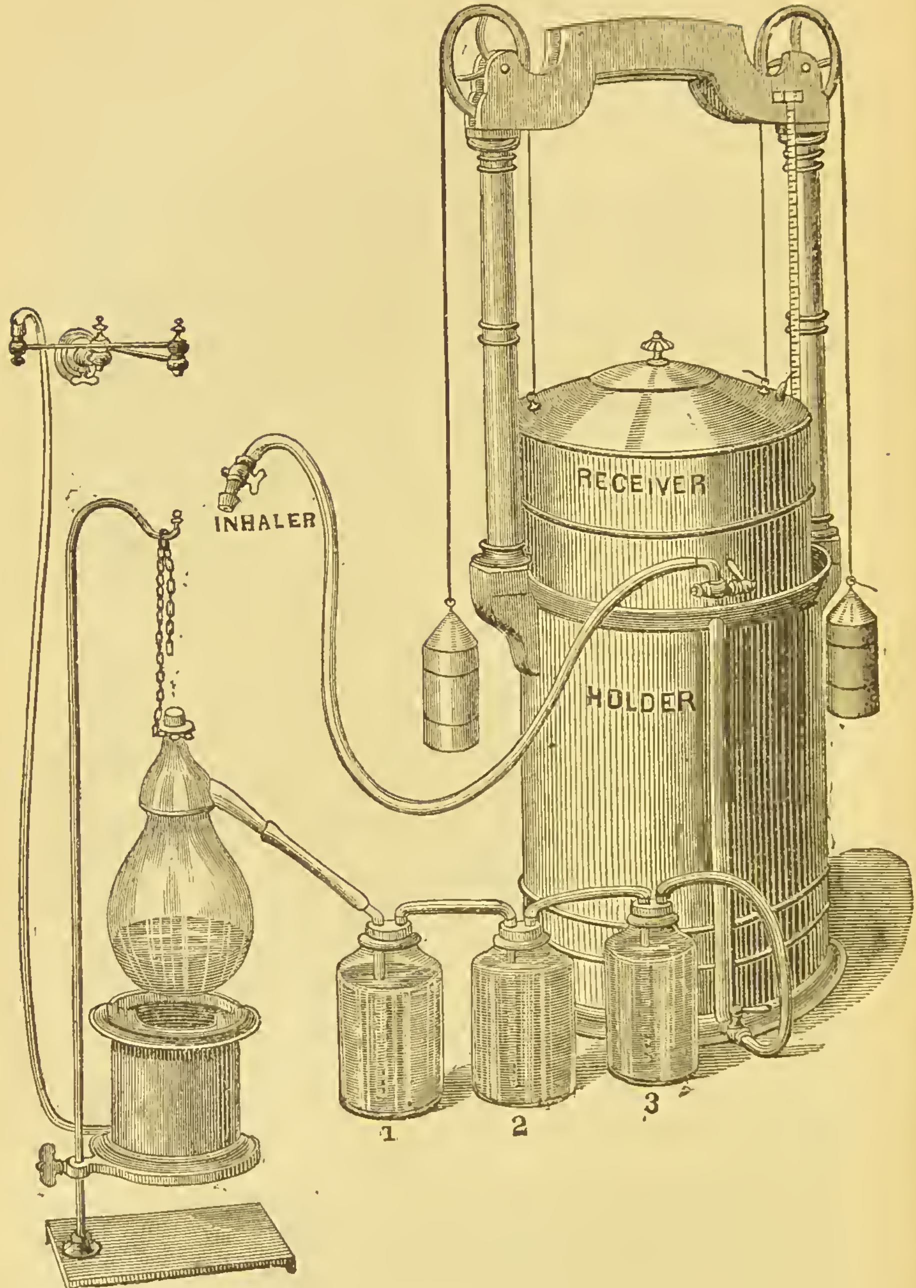

Fig. 10.

Mode of Preparation and Chemical Composition.—Nitrogen monoxide or nitrous oxide gas (NO—N_2O) is prepared from the nitrate of ammonia, which resolves itself into the gas and water, thus:—

$$NO_3NH_4{=}4HO,\ OH{+}2NO.$$

The nitrate of ammonia is a crystalline salt, but for convenience of introduction into the retort, should be in a granulated form, which can be obtained of the manufacturing chemist.

The second important matter is to be furnished with a convenient gasometer, an illustration of which is seen at Fig. 10, and these can be obtained from the various dental depots.* Having obtained one of these gasometers, care is required in the selection of the bottles for washing and purifying the gas. Fig. 11 represents a very good form, which is furnished with perforated rubber cork and glass tubes bent at right angles. The long tube is pierced with small holes at the bottom to compel the breaking up of gas and so insure its more thorough washing. In purifying the gas some employ a solution of sulphate of iron in one bottle and pure water in the other two. To remove chlorine gas, which is sometimes present, and can be noticed by its green color and irritating vapor upon the respiration, a small stick of caustic potash is added to one of the bottles containing the water.

Fig. 11.

When no chemical agents are employed in the purification of the gas it should be well washed through fresh water, and allowed to stand for some few hours over the water in the gasometer, to remove any impurities that may have passed over.

Fig. 10 represents the gasometer in position. The holder is first filled with water to within one and a half or two inches of the top; while this is being done take off the weights and open all the spigots, to allow the air to pass out

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* Samuel S. White, Philadelphia, New York, Boston, and Chicago.

and the receiver to remain in position. When the holder is filled, close the spigot and arrange the weights; it is then ready to receive the gas. The wash-bottles are placed as represented in the cut, Nos. 1, 2, and 3, which are connected one with the other, and to the retort and gasometer, by means of rubber tubing. The first bottle, No. 1, is placed next to the retort, and is simply used to catch the drip resulting from condensed vapor.

The long pipe of bottle No. 1 must not dip under the water, for the tubing thereby becomes choked with dense vapor, and the free passage of gas is interrupted.

Into wash-bottle No. 2 place about four ounces of sulphate of iron, and add sufficient water to cover the end of the dip-pipe, about one and a half to two inches.

Into wash bottle No. 3, Fig. 11, it is unnecessary to place anything but fresh water; yet some, fearing the chlorine, add a stick of caustic potash.

Sufficient water should be employed to cause the pipe which dips into the water to sink the same depth as it does in No. 2.

When the bottles are prepared, connect them by the piece of rubber tubing B, and to the spigot of the gasometer. If they are arranged properly, a current of air, blown into the tube intended to connect with the retort, will cause the water to bubble in the wash bottles, Nos. 2 and 3, and if the spigot A is open, the receiver will commence to ascend.

Having the bottles in readiness and properly connected, place the quantity of nitrate of ammonia, which will be required, into the retort (one pound of the granulated salt will produce about thirty gallons of the gas). D is a stove-like arrangement heated by gas-burners, with a sand-bath for holding and heating the retort. Connect the retort with the long pipe of the first bottle by the rubber tubing, and then open the spigot of the gasometer.

The heat must be applied gradually, first to melt the ammonia, about 226° F., and then to cause it to boil, and give off gas at 460° F., and so regulate this heat as to keep it boiling at 460° F. to 480° F., until it is nearly all decomposed. When the gas has ceased to come over, take a cloth and disconnect the retort from the tubing, and close the spigot of the gasometer.

The inhaling tube is attached to the spigot at the top of the holder. There is a register which shows the number of gallons of the gas in the receiver.

The water and solutions contained in the wash-bottles should be changed after each operation, and the water in the holder once in a month. When nitrous oxide gas is thus obtained, it is colorless, almost inodorous, of a sweetish taste. The chemical decomposition is as follows:—nitrate of ammonia resolves itself into nitrous oxide gas and water; thus, $NO_3NH_4=OH+2NO$. The heat necessary to cause active evolution of gas is stated to be 460° F., and this heat should be kept up, else a portion of the salt will sublime. The heat should never be allowed to rise above 482° F., as the nitric oxide is apt to be given off in the form of an orange-colored vapor. To determine the proper temperature a thermometer is prepared which can be passed into the cork and into the retort, so that no risk need be incurred by the introduction of poisonous materials into the gas.

Nitrous oxide gas as a liquid,* and as such is sold in form of cylinders.

Test of the purity of their liquid nitrous oxide is the appearance of the gas, and its freedom from red fumes as it comes from the retort, and the smell.

The complete apparatus consists of an iron cylinder containing at least one hundred gallons (usually more) of nitrous oxide, liquefied, to which is attached, by means of a nickel-plated union, the necessary tubing, gas-bag, and inhaler; nickel-plated wrench and key; the whole inclosed in a stout morocco case.

The inhaling tubing is made of the best material known for the purpose.

The gas-bags are made of stout muslin, thoroughly coated on both sides with pure "steam vulcanized" Para rubber.

Their parts are all cemented together before putting them in the heater, insuring a strong vulcanized seam.

The advantage of this method of construction is seen at once. If accidently cut or burnt, or mutilated on the outer surface, they are still good and serviceable, as the inner coating remains intact, and will prevent all leaking.

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* "History of discovery and mode of preparation of Liquefied Nitrous Oxide." Dental Cosmos, vol. xx., No. 3.

After this brief description of the process of its manufacture, as it has been set forth, I would remark that some use the fused and others the granulated nitrate of ammonia. I consider the granulated preferable only from the facility with which you can fill the retort. After the gas is made, it should stand over water from seven to ten hours before using, but this will do little toward insuring absolute purity of the gas; neither will washing it through solutions of iron and potash purify it perfectly. Should there be chlorine present (which is the poisonous element) in the ammonia, I have found that no amount of washing through solutions will obliterate it. The ammonia should always be tested before using, which is done by dissolving about a teaspoonful in half a tumbler of distilled water, and applying a few crystals of the nitrate of silver. If the ammonia be pure, the solution will remain perfectly clear; but should chlorine be present, it will show a clouded appearance, and the ammonia must be discarded altogether.

Next to pure gas, a perfect inhaler is the most essential object to the successful administration of nitrous oxide. It must be one with a tube large enough to admit the gas so freely that the most nervous, as well as patients with weak lungs, can inhale through it without exertion, and it must be perfectly air-tight. The majority of inhalers are so constructed that it is only with using great effort that patients can supply the lungs to their natural capacity, causing them to struggle for air, or to go to sleep with such feelings of suffocation and depression that they will drift into dreams of the most frightful character, and become almost unmanageable in their excitement.

It is necessary that the valves should be perfectly air-tight, so as to administer the gas free from any atmospheric air, one breath of which is sufficient to dilute to or three of the gas; and should there be a continual supply through the valves, it will require three times the quantity of gas, and the anæsthesia so produced will be of such a nature as not to render the patient utterly oblivious to the effects of the operation.

Inhalers which cover the face or any part of it are objectionable. In cases of gentlemen with beard, it is impossible to give the gas without the admission of some air. In in-

stances such as harelip, or where, from swelling or other cause, the muscles of the jaws become so contracted as to render it impossible to pass the mouthpiece between the teeth, I would recommend Dr. Barker's rubber hood, which is soft and pliable, and answers admirably in such cases, though not desirable for universal use. The color of the blood, as shown through the mucous membrane of the lips, is one of the principal guides to the condition of the patient during the inhalation of the gas; and if they are covered from view by the hood or otherwise, we have lost that means of rendering success to the operation.

Unlike chloroform and ether, the muscles of the patient become rigidly contracted while under the influence of nitrous oxide in a large number of cases, which render the use of props indispensable. These are made of hard wood of various sizes, and have strings attached to assure the patient against the possibility of swallowing them, and are placed in the mouth on the side opposite from where the tooth is to be extracted. By their use one has a fair opportunity to perform the operation to his entire satisfaction; but without them there is danger of the patient bruising and possibly breaking the front teeth by biting so hard upon the mouthpiece, with the probability of recovering from the effects of the gas before the mouth can be gotten open sufficiently wide to admit of the extraction of a tooth, or of an operation upon the mouth.

Nitrous oxide must always be fresh to insure success, though some have recommended it after it has stood over water one or two weeks, and even a month, but it is impracticable.

Dr. Rand, the late professor of chemistry at Jefferson Medical College, advocated the use of old gas; and to practically demonstrate the difference, some gas was allowed to stand for two weeks. Dr. Thomas then invited him to test between that and the new. He also invited his assistants, Drs. Green and Smith, and tested by inhaling with deep inspirations to the full capacity of the lungs, first of the new, then the old, and it required five times the quantity of the old to produce the same effect as with the new, which proved quite convincing. Besides requiring an excessive quantity, the anæsthesia produced by old gas is not so complete, but

the patient will generally reeeive some undefined impression of the operation, and will often complain of giddiness and a fulness in the head, and a feeling generally of malaise for the balance of the day. With fresh gas, sickness will never oceur, exeept with patients of very delieate organizations, such as are easily disturbed by nervous excitement, and those who are affected by the sight of blood or the contemplation of a wound of any kind.

In its pure state the gas may be given to almost any one, if judiciously administered, for Dr. Thomas has given it to a large number of patients afflicted with heart disease and consumption, also to cases subjeet to epilepsy, St. Vitus' dance, persons of apopleetie tendeney, and women advanced in pregnaney, and have never yet met with any but the most satisfaetory results.

Among the diffieulties which may be met with as having the appearanee of danger in administering nitrous oxide, the most eommon is constrietion or spasm of the glottis or "swallowing the tongue." The use of the prop cannot be overestimated in sueh eases. The patient becomes very dark in the face; there is a violent exertion of the diaphragm, and he presents every indieation of approaehing asphyxia, which by having the mouth well propped open, is very readily relieved by eatching hold of the tongue with a dry napkin and pulling it out of the mouth, and at the same time raising the body forward. As soon as the patient has taken two or three inspirations the tension is relaxed, and recovery will take plaee. I recall a case of this sort some time ago* in Exeter, England, where the patient died.

Another formidable symptom of danger is when your patient is attacked with syneope while under the influence of the gas. Be sure the air passages are open by pulling the tongue forward. Then, the patient being in a sitting posture, bring the head and body forward with eonsiderable violence, which will invariably prove suffieient. You may, however, meet cases whieh will require more effective remedies. The object is first to get the head on a level or below the heart, so the blood may flow freely to the brain, which is done by laying the patient on the floor; then throw cold water by

* Described in "The Dental Cosmos," May, 1873.

the tumblerful violently in the face. The most effectual remedy is to place the finger far down the throat, which will produce involuntary retching, and is the most efficient action to bring about restoration, after which you treat the patient as any ordinary case of fainting, giving a little brandy, and allowing him to lie on the lounge until he has become strong enough to walk in the fresh air, when he will soon recover completely.

In the hands of so skilful and careful an operator as Dr. Thomas, no great risk attends the employment of this anæsthetic; but those who are less skilful and are inexperienced should reject cases of great physical exhaustion, or patients with a feeble or fatty heart. The distension of the right cavities which accompanies the disappearance of the radial pulse, and the general lividity of the features, may be attended with some degree of risk, and the danger must be increased when, the muscles of the trunk and limbs being convulsed, the pressure of the contracting muscles upon the veins drives the blood forcibly towards the right cavities of the heart, and so adds to their distension.

PHYSIOLOGICAL ACTION OF NITROUS OXIDE GAS.

The marked resemblance between the effects produced by nitrous oxide and those resulting from asphyxia were observed by the earlier experimenters with ether; and a few eminent physiologists at once expressed this opinion. But at the present day it is not very generally entertained.

The following is a summary of the various facts bearing on the subject,—*i.e.*, in regard to the physiological action of nitrous oxide:—

It would seem that this accumulated evidence is not sufficient to show that the anæsthesia produced by the inhalation of nitrous oxide is simply asphyxia. Nitrous oxide gas produces in man, even when mixed with air, a feeling of exhilaration, which would indicate that it is not merely a passive agent. "Dr. Evans,* of Paris, states that he can call to mind no word in modern medical literature which is used with less definiteness of meaning, and

* Physiological action of nitrous oxide gas, by Thomas W. Evans, M. D., D.D.S., Paris, France.

which is more frequently misused, than this word, *asphyxia*. Understanding, however, by the word *asphyxia*, the condition which arises from an insufficient oxygenation of the blood, or from the accumulation in the blood of carbonic acid, he is by no means inclined to regard such conditions as identical with that produced by the inhalation of nitrous oxide. If there is a close resemblance between these, he states, there are also marked differences.

Nitrogen, when inhaled, is supposed to act upon the animal economy solely by the exclusion of oxygen. Nitrogen, when taken into the lungs, gives rise to no feeling of exhilaration, but to malaise and a sense of impending suffocation, and only occasions symptoms of narcosis and insensibility after an interval of time considerably greater than that usually found necessary when nitrous oxide is used.

In animals, after death following the inhalation of nitrogen, Dr. Evans has generally found less venous congestion, particularly of the portal system, than is to be observed after death from nitrous oxide. The blood is also lighter in color, and the liver nearly normal in appearance.

There is, however, one condition strikingly similar to that observable after death from nitrous oxide,—*i. e.*, the condition of the lungs. These organs are found neither voluminous nor collapsed, of a light pink or rose color, and generally with one or more small circular, well-defined ecchymotic spots, usually on their posterior surface. These spots, the *ecchymoses sous pleurales* of French writers, are considered by Briand and Chandé as peculiar to death by suffocation, and as distinguishing that kind of asphyxia from the asphyxia of drowning, hanging, and strangulation. The phenomena occasioned by the presence of carbonic acid were then carefully studied by experiments by Dr. Evans. This gas when pure is irrespirable; the mixture which he employed was thirty per cent of carbonic and seventy of common air. This mixture, when inhaled, produces the peculiar effects of carbonic acid,—loss of power of motion, loss of conscious sensation, and finally death. The insensibility is not preceded by a period of excitement, such as is witnessed during the inhalation of ether, and more especially of nitrous oxide. Again, the after effects following a prolonged inhalation of carbonic acid are ob-

served,—the sense of weariness, headache, loss of appetite, nausea, etc.; none of these signs of nervous disturbance are commonly seen after inhalation of nitrous oxide. This is an important difference, not only practically, but physiologically.

After death from nitrogen or nitrous oxide, the lungs are moderately crepitant, and the blood which escapes from an incision is more or less full of gas bubbles. In case of death produced by nitrous oxide, the bubbles will be found in the bronchial ramifications mixed with mucus, and in one or two instances, Dr. Evans found the trachea filled with rusty, frothy fluid, so common after drowning as to have been referred to by Dr. Riedell as almost pathognomonic of that cause of death. The local effects of nitrous oxide were found to be less marked than those produced by carbonic acid. They both act upon the blood-corpuscles so as to darken them. The lividity upon the lips, and the darkening of the mucous surfaces seen every day in the operating room after administrations of nitrous oxide are the result of this action. The inhalation of nitrous oxide is followed by an increased exhalation of carbonic acid; so is the inhalation of ether, chloroform, etc. Soon, however, according to M. Buisson, if the inhalation be continued, the exhalation of carbonic acid falls below the normal proportion to be found in expired air.

While it is perfectly evident that nitrous oxide has a strong affinity for the blood-corpuscles, it may usurp the place of oxygen in them, and prevent for a time that combination of oxygen with the hæmatin upon which the red color of the corpuscles is presumed to depend. Chemistry has not yet shown that it is decomposed in the blood, or exerts any of the chemical properties of oxygen on the constituent elements of the blood.

The conditions which obtain after the inhalation of nitrous oxide, ether, chloroform and other anæsthetics, are, specific toxical properties, which *first* stimulate, then narcotize, then destroy nervous action: by (*a*) an interference more or less marked with the oxygenation of the blood, and the consequent imperfect accomplishment of certain chemico-vital processes; by (*b*) a retention in the blood of a portion of the usual pulmonary exhalations: the two latter and

secondary conditions always finally co-operating with the specific action of the anæsthetic in the production of narcosis, the arrest of innervation, and in the suspension of every functional movement for a time with a rapid return to health. Latterly it has been disproved both by experiment and observation, *i. e.*, the theory which for a time prevailed in the United States, "that nitrous oxide acts upon the blood as an oxygenating agent." No experimental proof has yet been furnished that nitrous oxide is decomposed in the blood, or forms chemical combinations with it. It enters into the blood as nitrous oxide, and as such is eliminated. It will naturally be inferred from this statement that the presence of nitrous oxide in the blood is not indicated by the appearance (except change of color), as before stated. This was very conclusively proven by the late Dr. J. H. McQuillen, Professor of Physiology in Philadelphia Dental College, which proofs are here given with the illustrations.

Dr. Thomas, of this city, of the Colton Dental Association, placed his whole apparatus, with a large supply of recently made pure nitrous oxide gas, at the disposal of Dr. McQuillen and myself, and we repeated the experiments (see p. 176) in confirmation of the facts: that the gas had no positive poisonous qualities; second, that the blood-corpuscles were changed neither in form nor color under the microscope, and nitrous oxide is only known by the change of color, and even this varies much in individuals. A full report will be found at the end of his original communication.

The late Dr. McQuillen placed this communication at my disposal, with the cuts to illustrate it, and made such modifications of it as time and his mature judgment would seem to have dictated.

ACTION OF ANÆSTHETICS ON THE BLOOD-CORPUSCLES.*

In the October number of the *Dental Cosmos*, 1868, a report was presented of a series of experiments performed on

* Republished in the Boston Medical and Surgical Journal; Monthly Microscopical Journal, London; Deutsche Klinick, Berlin; Dental Cosmos, March, 1869; Correspondenz Blatt für Zahnärzte; Giornale di Correspondenza del Dentisti; Le Progrès Dentaire.

a number of animals, with the view of ascertaining whether the assertion made by Dr. B. Ward Richardson, that nitrous oxide, even under the most delicate manipulation, would prove destructive to life, could be possible. These experiments, which clearly demonstrated the assertion to be unfounded, were not performed in private, but in the presence of a number of gentlemen whose experience in the use of anæsthetics and whose scientific knowledge made them competent judges. First performed before the members of the Odontographic Society of Pennsylvania, they were repeated, after an interval of three weeks, on the same animals, in the presence of the members of the Biological and Microscopical Section of the Academy of Natural Sciences.

A month subsequent to the last-named occasion, one of these animals, a rabbit, in the presence of a number of gentlemen, was placed under the influence of nitrous oxide, and kept in a profound state of narcosis for one hour and five minutes, by alternating atmospheric air and nitrous oxide, removing the inhaler ever and anon for that purpose. Without question the animal could have been kept in the same condition double or treble the time without injury to it, for in a few minutes after removing the anæsthetic entirely, the animal was restored to consciousness, and leaped from the table to the floor, and for a number of weeks after this ran about my premises in a healthy and lively condition.

On examination, no perceptible difference was observable in the blood-corpuscles under the microscope, even after this lengthened exposure to the anæsthetic, when compared with the blood of another rabbit, which was not under its influence. This result induced me to examine into the statements made by Dr. Sansom relative to the action of anæsthetics on the blood-corpuscles, in his highly interesting and able work on chloroform.*

Prior to giving a description of my experiments in this direction, it may be proper to briefly refer to the prevalent theories on the physiological action of anæsthetics; also to the experiments performed and conclusions arrived at by

* Chloroform, its actions and administrations. By Arthur Ernest Sansom, M.B., London. Lindsay & Blakiston, Philadelphia.

Dr. Sansom. The view generally entertained is that first suggested by Flourens, that these agents act directly upon the nerve centres, producing regular and progressive modifications in the functions of the brain and spinal axis, first affecting the cerebral hemisphere, then the power of co-ordination in the cerebullum, then the conduction of sensation and motion in the spinal chord, and lastly, if the agent is pushed so far as to decidedly impress the medulla oblongata, suspension of respiration and circulation.

Dr. John Snow, regarding this theory as erroneous, and recognizing ether, chloroform, and other anæsthetics as non-supporters of combustion, advanced the theory that these agents, interfering with the introduction of oxygen into the system, induced their effect by the suspension of oxygenation. He therefore asserted that "narcotism is suspended oxygenation." This view is embraced and strongly advocated by Dr. B. W. Richardson, and in England apparently is being very generally adopted by writers on this subject. Dr. Kidd is, however, a prominent exception.

Dr. Sansom, accepting this theory, and knowing that nitrous oxide is not only an anæsthetic, but a supporter of combustion, recognized the necessity of presenting something more conclusive in the support of the view than had heretofore been offered. He therefore, in a paper read before the Royal Medical and Chirurgical Society, in 1861, as the result of certain experiments performed on the blood-corpuscles of man and animals out of the body, attributed the influence exerted by anæsthetics on the nervous system to their acting directly upon the blood corpuscles, by modifying their form and integrity, and indirectly upon the nervous system through this altered condition of the blood, by interfering with its oxygenation. In this work he describes a series of six experiments. Placing on glass slides, under a quarter-inch object glass, human and frog's blood, and subjecting them to the *direct contact* of alcohol, ether, and chloroform, which resulted quickly in the disintegration of the blood-corpuscles, leaving nothing but their nuclei and debris of the walls of the corpuscles. From these experiments on blood *out of the body*, he states in the work referred to:—" The effect, therefore, of these agents upon the

blood is solution—destruction. At first there is a change induced in the cell itself, and upon the nucleus in the case of frog's blood. The globuline of the blood is acted upon as it were by a caustic. Finally the blood-corpuscle is destroyed and the coloring matter set free." . . . From the foregoing facts and other considerations, the author considers that certain conclusions in regard to the action of anæsthetics are warrantable. Anæsthetics are agents which, when absorbed into the circulation, exert an influence upon the blood. They are shown to have the power of altering its *physical character* and *physical properties.* By an action upon its constituent (proteinous) elements, they tend to alter and by a profounder action to destroy its organic molecules. Its physical perfection being interfered with, its function is held in abeyance; the changes which contribute to constitute perfect life are retarded. Narcosis ensues, and is due, not to the influence of a circulating poison, but to the influence of an altered blood. Further on, he adds: "Narcotism (or, to speak more particularly, chloroform narcotism) is due not to a special poison that 'mounts up to the brain,' but to an altered blood. Then 'narcotism is a suspended oxygenation.' Whatever produces, to a certain extent, insufficient aeration of the blood, produces narcosis; and whatever produces narcosis, produces, by some means or other, imperfect aeration of the blood."

In drawing these conclusions, of an altered condition of the blood, from appearances presented by the blood *out of the body*, Dr. Sansom evidently leaves it to be inferred that somewhat if not exactly analogous results are produced on the corpuscles *in the body*, when human beings or animals are under the influence of anæsthetics by inhalation. After a patient, oft repeated series of experiments performed by me during the past three months, not only on blood out of the body, but also in cases in which human beings and animals have been placed under the influence of ether, chloroform, and nitrous oxide, and the blood drawn from them *prior* to and *after* the administration of these agents has been carefully *examined* and *compared*, the results obtained compel me to take very decided exceptions to such conclusions being justifiable in the premises.

First Series.—The experiments were as follows:—In my

examinations of the blood of man and animals, when ether and chloroform were brought in direct contact with it out of the body, under a fifth objective, the discharge of the nuclei and the disintegration of the corpuscles have invariably occurred, and in the frog leaving a result similar to that which is presented in the accompanying drawing (Fig. 12) from one of my specimens, wherein it will be observed that the field is occupied by the nuclei, débris of disintegrated globuline and corpuscles, in which the change of form, size, and other characteristics are most striking.

Fig. 12.

Frog's blood placed upon the slide, and chloroform brought in direct contact with it.

Second Series.—On placing, however, two glass slides containing frog's blood over watch-crystals, one holding chloroform and the other ether, and covering them with glass finger-bowls for half an hour, thus exposing one to an atmosphere of ether, and the other of chloroform, I found, on removing the bowls, and permitting the bloody sides of the slides to remain downward, until all the ether and chloroform had evaporated, that no disintegration or marked change in the form of the corpuscles was observable under the microscope, on comparing them with the blood of a frog unaffected by an anæsthetic. This forcibly demonstrates the difference between exposure to *direct contact* and the *vapor* of chloroform or ether, even out of the body.

Third Series.—Over and again in the presence of a number of gentlemen I have placed frogs under the influence of ether, chloroform, and nitrous oxide, and examined their blood-corpuscles immediately after without finding any disintegration or change in the form of the corpuscle. In one instance, a frog was so completely narcotized by chloroform that it died; the thorax of the animal was opened, the lungs cut out, and the blood obtained directly from that organ, and even here, where, if the inference of an altered blood was correct, there should have been discharge of nuclei, dis-

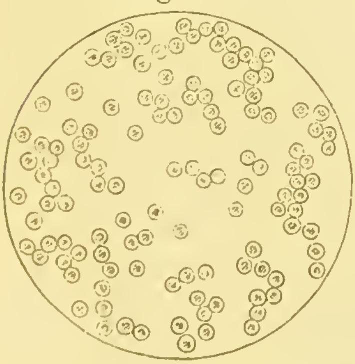
Fig. 13.

Corpuscles from the lungs of a frog which died under the influence of chloroform.

integration, or *marked* change in the form of the corpuscle, nothing of the kind was evident, as will be seen by the accompanying illustration, drawn from the slide on which the blood was placed. (Fig. 13.) As already intimated, the experiments in this direction have been prosecuted on every available occasion within the past few months; and I have not confined myself to frogs, but, in the course of vivisections on a large number of animals (rabbits, dogs, cats, and pigeons), to illustrate my course of lectures on physiology this winter, when these animals have been placed under the influence of ether or chloroform, their blood has been examined and no change in the form of the corpuscle has been evident.

Fourth Series.—The examination of the blood of a number of human beings, drawn prior to and after having been under the influence of ether, chloroform, or nitrous oxide, has yielded similar results, as will be evident from the accompanying illustration of the blood, obtained from a patient (Fig. 14) while under the influence of chloroform. Any one accustomed to microscopical examinations will recognize the normal characters of the corpuscles, so far as it is possible to present them in a woodcut.

Fig. 14.



Corpuscles of a patient under the influence of chloroform.

In conclusion, although it is not my intention in this communication to engage in an extended inquiry relative to how anæsthetics produced their effects, it seems to me that the above experiments demonstrate that we are not warranted in denying that

these agents act directly upon the nerve centres. All the phenomena, indeed, attendant upon their administration, the gradual exaltation of the cerebral functions followed by the progressive impairment and temporary suspension of the special senses, the loss of co-ordination on the part of the cerebellum, and when the agent is pushed too far, the arrest of respiration and circulation through the decided impression made upon the medulla oblongata, seem to favor this hypothesis, in contradistinction to the theory that anæsthesia is due to suspension of oxygenation.

Experiments with Nitrous Oxide by the late Doctor McQuillen, and Doctors Thomas and Turnbull, December, 1877.—A large-sized frog was placed under a glass jar holding five quarts of pure nitrous oxide, and kept there sixteen minutes. With the exception of some change in the color of the skin, there was no apparent impression made the first five minutes, as he jumped about when the jar was moved in the pneumatic trough. After that he assumed the position of sitting on the bottom of the jar, and maintained it until removed from the jar, when he was found in a semi-torpid state with the eyes wide open. On touching the eyes gently, the lids closed, and then opened immediately; the leg was retracted on pricking it with a pin. Two minutes after removal from the jar, he moved slowly about the floor, and ten minutes later hopped from a table on to the floor. After remaining out for thirty-five minutes, he was again placed under the jar, in a fresh supply of gas, and kept there for thirty minutes; on being removed he presented the same semi-torpid condition, and recovered from it in two minutes. In twenty minutes he was a third time placed in fresh nitrous oxide, and remained there fifteen minutes, with the same results as the previous trials; the confinement for one hour, in all, to the influence of nitrous oxide not having made any marked impression on him. Examined under one-fifth objective and B eye-piece, the blood-corpuscle presented no disintegrative discharge of nuclei, or change of form.

A small-sized rabbit was kept under nitrous oxide for two minutes, and in one minute after was completely restored to consciousness. He was then kept under the gas for five minutes consecutively, and recovered in one and a half minutes. After this, for twenty minutes off and on, the animal

was under the influence of the gas. In three minutes after removal from it he was running around the room as though nothing had occurred. The blood examined under the microscope gave no evidence of disintegration of the blood-corpuscles.

To test the quality of the gas used, Doctors McQuillen, Thomas, and Turnbull inhaled it, and each one was completely under its anæsthetic influence.

If we assume that the influence of anæsthetics is dependent not upon a direct action on the nerve centres, but upon an altered condition of the blood and the suspension of oxygenation, we must apply the same principle to all diffusible stimulants.

It will be noticed that it was in 1868 Dr. McQuillen published his experiments upon nitrous oxide. On the 7th of December, 1869, Dr. Jeannel read a paper* before the French Academy of Medicine, on the protoxide of nitrogen or nitrous oxide as an anæsthetic agent. He states that there is no record of a fatal case from the use of the drug, notwithstanding its frequent application. He reported a number of careful personal experiments. He dwells at some length upon the rapidity with which the effects of this drug pass away, followed by the proper exercise of the natural functions, and concludes that his own and M. Limouzin's experiments authorize the presumption that this gas is an anæsthetic much less dangerous than ether or chloroform.

In August, 1870, Dr. Robert Amory published a number of experiments on man and animals† to show the physiological action of nitrous oxide, He commences his experiments with this proposition:—

"I have not, as yet, been able to find how the peculiar effects of this so-called anæsthetic agent are explained; nor has any one *directly* stated that the action may be explained by an accumulation of carbonic acid in the blood. A direct proof of this supposition it would be a difficult matter to give. An approximate idea I have attempted to show by a few experiments."

After making his experiments, which he gives in a table

* Gaz. Hebdomadaire, 1869, p. 786.

† New York Med. Journal, August, 1870. Republished by James Campbell, Boston, 1870.

at page 13 (see pamphlet), he observes:—"Now if we examine this table carefully, we should merely compare the figures in the last column with each other, as also the effects produced by this agent upon the same animal. If we do so, we shall find that the gas diminishes the amount of carbonic acid exhaled by almost one-half. This, then, would lead us to suppose that the effects produced by inhaling this gas may be due to the accumulation of carbonic acid in the blood; but a plausible explanation is that the oxygenation of the blood is prevented, and carbonic acid, the result of combustion, is withheld; the effects are by no means so rapid as when the agent is inhaled. Again, I do not quite accept a theory which supposes that an accumulation of carbonic acid in the blood will cause asphyxia and death in twenty minutes." At page 18 there is a paragraph which strongly corroborates Dr. McQuillen's experiments. "Two or three times it has happened to me, when I had thought an animal dead from asphyxia, after the inhalation of this gas, to be surprised by voluntary respiration recurring after I had removed the muzzle. In fact, I have now two dogs alive who have not respired for *one whole minute* several times when undergoing an experiment. Never has an animal died *unexpectedly*, and it was always very difficult for me to cause *asphyxia*, if the smallest modicum of air passed into the lungs."

At page 29 the author finally states:—"Having proceeded thus far in my writing, I came across, accidentally, a lecture of Professor George Johnson, in the number of the *Medical Times and Gazette* for April 3, 1869. I was exceedingly surprised to see a confirmation of his theory in regard to the anæsthetic action of nitrous oxide. What he had arrived at by careful reasoning, I have been able to obtain by actual experiment. For example, he says:—

'Nitrous oxide is a rapidly-acting anæsthetic, causing complete unconsciousness in less than a minute. At a high temperature it is an oxidizing agent, but at the temperature of the body it gives up no oxygen, but is exhaled again unchanged. When inhaled in place of atmospheric air, it rapidly replaces the oxygen of the blood, and, this being done, the functions of the brain are completely suspended, and there is a state of profound coma, which quickly passes

off when air is again allowed to enter the lungs. . . There is no reason* to conclude that the inhalation of either nitrous oxide or nitrogen causes an accumulation of carbonic acid in the blood.' Before this, he says:—'To produce oxidation of the brain, there must be (1) a free current of blood through the capillaries of the brain; (2) the blood must be duly aërated or oxygenized; (3) the blood must be unmixed with any material which prevents or impedes the giving up of oxygen from the blood to tissues.'"

Then our author and experimenter says:—

"If we accept these three rules for the preservation of the nerve functions, of course, if one be wanting, the nerve functions are suspended. Now the experiments XIV, XV, and XVI, taken in connection with the accompanying sphygmographic traces (which are given), show an increase of capillary tension, with, as we should suppose, increased arterial pulsations, but finally arrest of capillary pulsation in the brain. At this stage anæsthesia occurs. When the pulsation recommences and the tension falls, consciousness sets in. This effect, then, is a violation of Rule 1. Again, the blood having no oxygen to give up in the capillary system, there is a violation of Rule 3."

We do not think either Dr. Johnson or Dr. Amory has proven his propositions by facts; the one resorts to theory alone, and the other to supposition after experiments, by supposing an increased number of arterial pulsations, which is not proven, as the pulse before inhalation is increased in frequency by the nervous excitement, and always decreases when the patient has begun to inhale the nitrous oxide. This fact has been recently proven by a large number of experiments.

We are fully convinced by experiments on animals and man that when death occurs, it is the result of syncope, caused by a capillary stasis of the blood, and the true anæsthetic action was discovered by Flourens that nitrous oxide acts directly upon the nerve centres, producing regular and progressive modifications in the functions of the brain and spinal axis, first affecting the cerebral hemisphere, then the cerebellum, and lastly, medulla oblongata, with suspension of respiration and circulation.

* Vide experiments Nos. I, IV, etc.

MODE OF ACTION OF ANÆSTHETICS.

We have already given our own results and those of others as to how anæsthetics act under the several agents, viz.—ether, chloroform, nitrous oxide gas, and chloral. Their true action is still a subject of dispute; and I avail myself of the recent investigations of Dr. C. Binz, of Bonn, and of Heinrich Ranke, to further illustrate this complex subject. Binz concludes an article on the official sleep-producing substances in the *Archiv für Experimentale, Path u. Pharm.*, by saying that these agents possess the power of producing a kind of coagulation on the substance of the cerebral cortex, whilst other agents, though nearly allied to the former in chemical composition, do not possess this power. Morphia, chloral, ether, and chloroform possess, these latter maintain, a strong affinity for the substance of the cortex of the brain in man ; and when they are introduced into the blood, they enter into combination with the cerebral substance, opposing or impeding the disintegration of the living substance, and thus rendering it unfit to discharge the functions required of it in the living state. In a paper on the subject in the *Centralblatt*, Aug. 25th, 1877, Heinrich Ranke* observes that protracted study of the effects of the anæsthetics has led him to very similar conclusions in 1867. He has found that the action of chloroform, ether, and amylene on frogs first produces a condition in which, just as in poisoning by curare, no contraction can be induced in muscle by any kind of irritation applied to the motor nerves, though the muscular tissue itself reacts to direct stimulation, and the current in the nerve remains constant both in force and direction. In a later stage of the anæsthesia, the muscular tissue itself ceases to respond to the most powerful induction currents, though its proper electro-motor force remains unweakened ; and lastly, at a still more advanced stage, the whole muscular tissue of the body passes into a condition of rigor. He has further found that a solution either of albumen from the brain or of myosin from muscle in very weak salt and water is precipitated by the vapor of the three above-named anæsthetics, and that their power of producing muscle rigor in the case of muscle depends on the coagulation of the myosin.

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* Translated in the London Lancet, November 24, 1877.

Additional experiments have lately been instituted by Ranke, which demonstrated that not only chloroform and chloral hydrate, when injected into the arteries, caused rapid stiffening of the muscles, but that the same influence was exerted by *ether*, *amylene*, *bromoform*, and *bromohydrate*; whilst when tannin, cupric sulphate, mercury chloride, ferric sulphate, or spirits of wine were injected, though strong fibrillar contractions occurred, and coagulation of the blood followed by death, in no instance was rigor produced. Idoform indeed appears to form an exception to the conclusion that the rigor producing action of the anæsthetics is something peculiar to them, for it is not known to possess anæsthetic properties. If injected in solution in ether, rigor is immediately produced, but ether has itself a stiffening action on muscle. Nevertheless, Ranke thinks he can distinguish between the action of the idoform, which is immediate and tense, and that of the ether, which comes on later and is less powerful; and he attributes the failure of the idoform to act as an anæsthetic to its insolubility merely, which, as it were, masks its proper action. Ranke was unable to find that solutions of morphia were able to exert any coagulating influence on muscle, either within or without the vessels. It may be asked what relation does the action of these agents on the muscle bear to the process of anæsthesia, and in reply Ranke observes that anæsthetization obviously cannot depend on such a complete coagulation as admits of no further change, since the effects produced by anæsthetic agents are but transitory. But it is very conceivable that an action which in its final stages leads to coagulation of albumen, may, in its earlier stages, render, to a certain extent, fixed and immovable the albuminous molecules in the ganglion cells of the brain, and afterwards in nerve and muscle; the effect passing off with the removal of the cause.

This same hypothesis was maintained by the late Claude Bernard on similar grounds, several years prior to the publication of even that of H. Ranke. The editor of the *Lancet* adds: "It would have been exceedingly interesting if the view of Binz, to the effect that morphia acts also as a coagulating agent upon the ganglion cells could be corroborated: since, if such were the case, it would tend to show

that the various kinds of anæsthetics act essentially in the same manner.

A committee appointed by the British Medical Association reports as follows, in the *British Medical Journal* of January 4th, 1879:—

With reference to the physiological action of anæsthetics, our attention has been mainly occupied with three inquiries, viz.:—1st. The changes, if any, produced in the gases of the blood; 2d. The changes effected in the gases of respiration; and 3d. The effects of anæsthetics on nervous conduction, and on mental phenomena, as observed on man. All of these experiments have been of a very laborious character, involving the use of complicated apparatus, and the methods employed can yield satisfactory results only after considerable practice.

First. The effect on the gases of the blood.—The blood was collected by means of a graduated tube filled with mercury and provided with a glass stop-cock at each end. The upper end was placed in communication with the aorta or the inferior vena cava of a rabbit (immediately after it had been deeply anæsthetized), by means of a canula, and by opening the stop-cocks, the blood flowed in at the upper end, replacing the mercury which escaped at the lower extremity of the tube. It was thus possible to mix the blood without any admixture of air. The small portion of the tube above the stop-cock was then washed, and filled with a boiled solution of salt, and attached by an India rubber tube to the tube entering the receiver of a Pflüger's air pump. The lower end of the tube containing the blood was then inserted in mercury. On opening the stop-cock of the receiver and those of the tube containing the blood, the mercury in the vessel below displaced the blood, which flowed into the enhausted receiver, frothing and evolving gas. The gas was collected in the usual manner, and carbonic acid and oxygen were successively estimated by known methods. Some boiled solution of tartaric acid was then allowed to enter the receiver, and displaced a further quantity of carbonic acid, which was in turn collected and estimated. A sufficient number of experiments have not as yet been made to permit of giving results.

Second. The effect on the air breathed.—The gases of res-

piration were analyzed as follows:—The animal was placed in a tin box with glass sides, provided with a lid of thick brass plating above, fitting over a square hole, and secured tightly by means of a washer of India rubber, and eight strong screw nuts. Very great difficulty was experienced in procuring an air-tight joint, but the above means proved the best. Air, deprived of carbonic acid by passing through potash solution, and then dried over sulphuric acid, entered the box by means of a tube at one side, and drawn off at the other through a tube filled with calcium chloride, and then passed through a set of bulbs filled with a solution of caustic potash. The increase of weight of the bulbs in a given time gave the amount of carbonic acid expelled. An attempt was also made to estimate oxygen by passing the air, after absorption of carbonic acid, over a strong solution of ammonia; enough of that gas is carried over to insure the combination of all the free oxygen with the hydrogen of the ammonia, when the mixture was passed over red hot copper. Caustic baryta was used to absorb the water formed. The residue consists of a mixture of baryta and nitrogen, and after removal of the ammonia by sulphuric acid, the remaining nitrogen is so pure that it does not tarnish melted sodium when a stream is directed against it.

The amount of carbonic acid accordingly is given by increase of weight in the potash bulbs, and that of the oxygen by increase of weight of the tube filled with caustic baryta, after multiplication by eight and division by nine, to reduce water to oxygen,—for water contains eight-ninths of its weight of oxygen.

After ascertaining the normal amount of carbonic acid exhaled and of oxygen absorbed by an animal in a given time, it was removed from the box, anæsthetized, again placed in the box, and the gases of respiration estimated. Without giving detailed results (which should have been done) it may be stated that the effect of anæsthesia with chloroform is to increase the amount of carbonic acid exhaled within a given time.

Third. Effects on Nervous Phenomena.—Several curious facts have been elicited with regard to the effects of small doses of chloroform and ether on the rapidity of nervous and mental processes. By a refined method of experiment-

ing with Regnatt's chronograph, it was ascertained that a few respirations of air containing chloroform or ether produced remarkakle retardation in the time of signalling back that a visible impression had been perceived, although the person operated upon was quite unconscious of any such delay. These experiments are interesting chiefly from a psychological point of view.

Investigations upon the protoxide of nitrogen* by Drs. Jolyet and T. Blanche, which appeared in the *Archives de Physiologie*, for July, of the same year:—

"In view of the conflicting opinions regarding the physiological effects of nitrous oxide gas, none of which can at the present time be considered as established, Messrs. Jolyet and Blanche have recently instituted a series of experiments to determine with precision the following questions:—

"*a.* Can the protoxide of nitrogen be regarded as a supporter of respiration?

"*b.* Has it anæsthetic or other qualities capable of being utilized in medicine?

"*c.* Is the protoxide of nitrogen a respirable gas for plants and animals?

"*Plants.*—We endeavored first to determine whether grain would germinate in a medium of pure protoxide of nitrogen, and, if germination had already commenced, whether it would continue under these conditions. From the experiments of Saussure it is known that the germination and development of plants are impossible in a medium containing no oxygen; seeds never sprouting in nitrogen, hydrogen, carbonic acid, etc. We then came to consider whether nitrous oxide—a gas unstable and rich in oxygen—would be able by that oxygen to support the respiration of plants. We therefore placed seeds of cress and barley upon a damp letter-paper in an atmosphere of pure protoxide of nitrogen. At the end of nine days in one experiment, and five days

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* Philadelphia Medical Times of September 27th, 1873, translated by Dr. Frank Woodbury.

NOTE.—In republishing this article at this time, it is to satisfy a desire on my part to withhold no experiments that will throw light upon the action of this important agent, although not agreeing with the conclusions herein expressed.

in another, the seeds had not even commenced to sprout; while other seeds, under the same conditions, but in ordinary atmospheric air, entered into complete germination as soon as the third day. Permitting then a small portion of air to enter the receiver where the seeds had not sprouted, we saw, in both cases, germination produeed in two or three days.

"In other experiments we have placed seeds in the act of sprouting in pure nitrous oxide; the development was arrested, and again resumed when a portion of air was allowed to enter the receiver. We have proved further that in protoxide of nitrogen plants do not exhale carbonic acid.

"From these different experiments we believe that we may conclude that the oxygen of the protoxide of nitrogen cannot be utilized by plants for respiration; and if the eontrary has been asserted, it is beeause the gas experimented upon, not being perfectly pure, contained a small quantity of oxygen, and we know that a very small quantity of oxygen only is needed for the commencement of germination.

"*Animals.*—Frogs were placed, for comparison, in receivers containing respeetively pure protoxide of nitrogen, carbonic acid, earbonie oxide hydrogen, and nitrogen. While those plunged in hydrogen, nitrogen, and carbonie oxide only expired after two or three hours' stay in these gases, exhibiting at the termination stupor and drowsiness (as Jean Muller had already proved), those placed in earbonic acid were seized at once, and died quiekly. The frogs placed in the nitrous oxide succumbed at the end of two hours' exposure to the gas.

"We placed a sparrow under a jar eontaining twenty-five litres of protoxide of nitrogen; where death took place at the end of thirty seeonds. One placed for eomparison in a jar containing hydrogen, died in the same time.

"A guinea-pig inspiring pure nitrous oxide by the trachea died in two and a half minutes.

"In the same way a rabbit died suddenly at the end of two minutes and twenty-four seconds of respiration of pure nitrous oxide.

"From these experiments, and others which we will not here recall, we are compelled to say that ehemically-pure

protoxide of nitrogen cannot support respiration in animals or plants. We may, therefore, here repeat the remark made above, that if certain authors have believed themselves able to demonstrate that this gas is one which can support respiration, it is because they experimented with impure nitrous oxide, containing a quantity more or less great of oxygen, according to the time more or less long that the animals lived in the gaseous compound.

"*b*. Does the protoxide of nitrogen possess any specific properties?

"If pure nitrous oxide is not able to support respiration in plants and animals, is it a gas inert, like hydrogen or nitrogen? Or, on the contrary, being very soluble (water dissolving four-fifths of its volume), will it enter into the circulation by the way of absorption, and dissolving in a greater or larger amount of blood, be carried to the nervous centres, there to produce peculiar effects, stupor, anæsthesia, etc.?

"With this in view we have studied the phenomena presented when animals are made to breathe pure nitrous oxide, or an artificial atmosphere of pure protoxide of nitrogen and oxygen.

"Frogs placed in pure protoxide of nitrogen exhibit the following phenomena: After three or four minutes, more or less marked diminution in the respiratory movements of the throat and sides, soon followed by stupor and drowsiness, from which he rouses himself at intervals more or less prolonged. The animal spontaneously, or following excitation, makes a few respirations, and if placed on his back regains his natural position, and soon resumes his former stupor. In this condition the frog remains perfectly sensible to pinching of his toes, sensibility which can be proved after the expiration of forty-five minutes in the gas.

"A guinea-pig was made to breathe, by the trachea, from a bag containing eight litres of pure nitrous oxide. Thirty-five seconds after, the animal was perfectly sensible to pinching of his paws. After forty-five seconds respiration was labored, but sensibility remained intact. On allowing the animal to breathe air freely, he revived in a few seconds.

"Half an hour later the same animal was again made to breathe the pure nitrous oxide gas. After one minute and

forty-five seconds, sensibility was still preserved ; after two minutes and twenty seconds it was extinguished ; and death supervened in two minutes and thirty seconds from the time the experiment was commenced.

"A rabbit was made to respire pure protoxide of nitrogen. After one minute and forty-five seconds the animal struggled and showed signs of asphyxia, but sensibility was proved to resist. On withdrawing the nitrous oxide and allowing him to breathe the air the animal rapidly recovered.

"In another experiment upon the rabbit, sensibility existed even after two minutes and twenty-four seconds; at this moment the respiration terminated abruptly, but we were able to restore the animal to life after some moments of artificial respiration.

"The preceding experiments show that pure protoxide of nitrogen produces asphyxia with all its signs. Having noticed that anæsthesia occurred at the moment the animal's arterial blood became black (and knowing that when animals are subjected to asphyxia anæsthesia takes place as soon as the arterial blood only contains two or three per cent. of oxygen), in order not to attribute to nitrous oxide the concomitant anæsthesia, which may be attributed to pure and simple asphyxia, we have made the following experiments.

"We added protoxide of nitrogen and oxygen in different proportions, so that the mixed gases contained eighteen to twenty-one per cent. of nitrous oxide. In this way the animal had at his disposal a quantity of oxygen almost equal to that existing in atmospheric air, while at the same time the combination was sufficiently rich in nitrous oxide to produce its specific effects, if it really possessed any.

"Frogs remaining twenty-four hours in a mixture of four-fifths protoxide of nitrogen and one-fifth oxygen did not present a single appreciable phenomenon ; sensibility when the toes were pinched was very evident.

"Two other frogs, after remaining five days in a receiver containing three hundred cubic centimetres of oxygen to sixty per cent. and one litre of pure nitrous oxide, did not show at the end of this time either stupefaction or anæsthesia.

"At twenty minutes past five o'clock we placed two sparrows for comparison, the one under a bell jar containing

air, the other under a similar jar containing oxygen and nitrous oxide in proportion of the gases of the atmosphere.

"Seven o'clock.—There was some trouble in respiration noticed equally in both birds.

"Half past seven.—We left the sparrows panting, puffed out, and both alike.

"Nine o'clock.—We found the birds dead.

"On making an analysis of the air remaining in the jars, we found in the one containing air:—

Carbonic acid,	11 per cent.
Oxygen,	6 " "

"In the one containing nitrous oxide and oxygen:—

Carbonic acid,	12 per cent.
Oxygen,	5.8 " "

"At twenty minutes to three, p. m., we put a sparrow into a mixture of four litres of nitrous oxide and six hundred cubic centimetres of oxygen. At half past three, p. m., the same; no change in the appearance of the bird.

"Four o'clock, p. m.—He commenced to pant. We then collected the gas in the jar, which gave 9.2 per cent. of carbonic acid on analysis. The bird rapidly recovered.

"At quarter to seven, p. m., we placed a sparrow under a two-litre receiver, containing nitrogen and nitrous oxide in the proportion of eighteen to eighty-two per cent. The bird remained quiet until quarter to eight, p.m., when his respiration became labored. When seen at nine, p. m., he was panting, and death took place at quarter past nine, p. m. The analysis of the gas in the jar gave twelve per cent. of carbonic acid and three per cent. of oxygen.

"A small dog was made to breathe a mixture of protoxide of nitrogen and oxygen in the proportion of atmospheric air. By means of a caoutchouc muzzle and the valves of Muller, he only inspired the gas contained in the bag, the expirations going outside, so that there could be no complication from asphyxia by the carbonic acid. The animal breathed this mixture for twenty-two minutes, during all of which time he remained insensible without stupor or drowsiness; galvanization of his sciatic nerve by a feeble current produced pain, and when he was called he gave signs of attention.

"These experiments show, therefore, that animals are able to breathe an artificial atmosphere containing eighteen to twenty per cent. of oxygen and sixty to eighty per cent. of nitrous oxide, during a time sufficiently long, without showing any manifest phenomena, and, above all, without exhibiting anæsthesia.

"As the protoxide of nitrogen is very soluble in water, which dissolves four-fifths of its volume, it was of interest to discover what quantity of it was in solution in the blood of those animals which breathed the artificial atmosphere, and nevertheless showed no diminished sensibility, for comparison with that in the blood of animals breathing pure nitrous oxide, taken at the moment anæsthesia appeared, in order to decide what share in this phenomenon to attribute to the nitrous oxide. It is also equally important to determine the quantity of oxygen existing in the blood at the same moment.

"But we will first show rapidly the method of analysis of the gases of the blood which we have employed and have used also in the analysis of the mixed gases, composed of oxygen, nitrous oxide, and nitrogen.

"We have adopted the following, which M. Gréhaut kindly pointed out for us:—

"The mixture to be analyzed, composed of oxygen, protoxide of nitrogen, and nitrogen, is introduced into the eudiometer.

"Let v = the volume of the mixed gases, x = the oxygen, y = the nitrous oxide, and z = the nitrogen; then we have—

$$x+y+z=v.$$

"By introducing a quantity of hydrogen b, we have in the eudiometer $v+b$. Now, if a spark be passed through this, the remainder may be expressed by r, and the amount lost will equal $v+b-r$.

"But x of oxygen combines with $2x$ of hydrogen to form water, making a loss of $3x$; y of the nitrous oxide contains one-half y of oxygen, which combines with y of nitrogen,* only y of hydrogen disappearing; we have then—

$$v+b-r=3x+y.$$

* (According to Bloxam, when NO is decomposed, it gains half a volume,—two volumes of NO containing two volumes of N, and one of O.—Tr.)

"We add to r a volume d of oxygen, and there is in the receiver a volume r+d; on passing the spark, there remains r^1; $r+d-r^1$ is the second volume disappearing, of which two-thirds are hydrogen, which we will call e.

"Having introduced a volume b of hydrogen, the $b-e$=the hydrogen used in the first combustion. But x of oxygen required 2x of hydrogen, and y of the protoxide of nitrogen used y of hydrogen; therefore—

$$b-e=2x+y.$$

"It remains to resolve these three equations with three unknown quantities:—

$$\begin{aligned} x+y+z &= v. \\ 3x+y &= v+b-r. \\ 2x+y &= b-e. \end{aligned}$$

"From which the values of x, y, and z are easily determined.

"This said, we will relate some experiments with the analysis of the gases of the blood determined in the preceding manner.

"A dog breathing the surrounding air through the valves of Müller had in one hundred cubic centimetres of arterial blood—

Carbonic acid, ...	48.8	per cent.
Oxygen, ...	21	"
Nitrogen, ...	2	"

"He was then made to breathe from a bag containing a gaseous mixture of sixty-two per cent. of nitrous oxide, twenty-one per cent. of oxygen, and seventeen per cent. of nitrogen. The animal took seven minutes and thirty seconds to inspire fifty litres of this mixture; and during all this time his eye remained sensitive, and he took notice when his toes were pinched. The analysis of the gases of the blood made then, gave for each one hundred cubic centimetres of red arterial blood—

Carbonic acid, ...	46	per cent.
Oxygen, ...	19.7	"
Nitrous oxide, ...	29	"
Nitrogen, ...	0.3	"

"The same animal, having rested half an hour, was made to breathe pure nitrous oxide gas for one minute and forty-

five seconds; he was then much troubled in his breathing, but still remained sensible. On making then an analysis of the dark arterial blood, we found—

Carbonic acid,	37	per cent.
Oxygen,	5.2	"
Nitrous oxide,	28.1	"
Nitrogen,	0.7	"

"A second dog, breathing in the manner already explained from a bag of nitrous oxide, was found to be insensible at the eye and to pinching after three minutes. The analysis of the gases of the blood then made gave for each one hundred cubic centimetres of very dark arterial blood—

Carbonic acid,	36.6	per cent.
Oxygen,	3.3	"
Nitrous oxide,	34.6	"

"A third dog, breathing the nitrous oxide from a bag, was still somewhat sensible at the third minute; was found completely insensible to the electrization of the sciatic nerve after four minutes. Analysis of the black arterial blood then gave—

Carbonic acid,	34	per cent.
Oxygen,	0.05	"
Nitrous oxide	37	"

"We might here relate other experiments, but think that these will be sufficient to enable us to draw the following conclusions:—

"When there is in the arterial blood of dogs that breathe an artificial atmosphere of protoxide of nitrogen and oxygen, almost the same quantity of nitrous oxide in solution as that found in the same animals breathing, until asphyxiated, pure protoxide of nitrogen, we cannot attribute the anæsthesia which then appears to the presence of the nitrous oxide in the arterial blood. The cause of the anæsthesia is naturally found to be the result of asphyxia, from the privation, more or less complete, of oxygen from the arterial blood. We know, in short, that when there is no more than two or three per cent. of oxygen in the arterial blood anæsthesia commences to appear.—(P. Bert.)

"We conclude our article with the following propositions:

"The protoxide of nitrogen, chemically pure, is not able to sustain respiration in animals any more than in plants; the

combustion in which respiration consists not being sufficiently energetic to decompose the nitrous oxide gas.

"Breathed pure by animals, the protoxide of nitrogen is an asphyxiating gas, which produces death, with all the usual signs of asphyxia, by strangulation, or by respiration of the inert gases (nitrogen and hydrogen), and in almost the same time.

"Breathed pure, if the nitrous oxide produces anæsthesia, it is by privation of oxygen from the blood, insensibility showing itself when the arterial blood commences to have only from two to three per cent. of oxygen. The arterial blood is then very black, and contains thirty to forty per cent. protoxide of nitrogen.

"Animals are able to live by breathing an atmosphere of protoxide of nitrogen and oxygen in the proportion of the gases in the air, the nitrous oxide replacing the nitrogen, without producing troubles of sensibility. The arterial blood then contains thirty to thirty-five per cent. of protoxide of nitrogen. Birds plunged in a similar confined atmosphere behave like those placed under a bell-jar of the same capacity containing air, and die after having nearly equally consumed the oxygen in the receivers and formed as much carbonic acid.

"The protoxide of nitrogen being an irrespirable gas, and possessing none of the anæsthetic properties that have been attributed to it, its employment can only be dangerous, and should be, under that title, proscribed from medical practice."

THE SPECTROSCOPE, AND ITS RELATIONS TO ANÆSTHETICS.

A recent writer, Dr. Waterman,* who has experimented with this beautiful instrument, states the following:—

"Through the agency of the spectroscope has been supplied the missing link to our chain of reasoning. *The shadowy field of theories has been cleared up, the laws governing the relations of anæsthetics in contact with the blood current have been ascertained, and rational progress has*

* The Beauties of the Spectroscope, and its Relations to Anæsthetics. Proceedings of Am. Den. Con. and Southern Den. Ass. and the Den. Ass. of Md. Held at Oakland, Garrett County, Md., August, 1877. Baltimore: Innes & Co., Printers.

been made to insure safe anæsthetics. I have abiding faith in the progress of chemical science that it will finally point out an agent, from the almost inexhaustible materials at its command, that will satisfy all ends of surgical requirements, —an anæsthetic that, while it will annihilate temporarily all sensation, will leave consciousness and vitality intact."

We shall now pass to the article on nitrous oxide gas, and let our readers judge for themselves of the rational progress made, and the clearing up of theories by positive experiments justifying or not the condemnation of this, the only anæsthetic as yet discovered which possesses such a wonderful record. We will give our experiments and observations, and while quoting from others in regard to the injurious effects, have not withheld any of all the well-authenticated cases of deaths from this agent.

"It has been demonstrated by Herrman, and verified by Hoppe Seyler, Gorup Besanez and W. Preyer, that nitrous oxide gas possesses a keen affinity for oxodized blood, as well as for artificial oxy-hæmato-crystalline in solution. The affinity is so strong that when a current of this gas is passed through a solution saturated with carbonic oxide hæmato-crystalline, the carbonic oxide is driven out by the nitrous oxide, which takes its place volume for volume.

"When a current of nitrous oxide gas is forced through a slightly alkaline solution of hæmato-crystalline, the solution loses its dichroism and assumes a slight cormoisin red color. When the solution is placed before the spectroscope, we observe that in proportion that the gas exerts its influence, the two bands between D and E fade away, and disappear finally altogether; and there is a moment, says Preyer, 'when the spectrum is continuous.'

"The disappearance of these blood-bands means here, as it means in other instances, disappearance of oxygen from the blood, or complete deoxidation, and unless a fresh supply is speedily furnished, suffocation must ensue.

"As the action of nitrous oxide gas upon the blood solution continues, soon after the fading away of the two bands, two new bands appear resembling the oxy-blood bands, but differing from them in position and depth of shading,—they are paler and more blurred in outlines.

"I before told you that when blood is simply deprived of

its oxygen, the blood reduction band would follow the disappearance of the two oxidized broad bands, and that then the simple contact of atmospheric air with such deoxidized blood solution would suffice to cause the reappearance of the two oxygen blood-bands.

"But we see here that instead of Stokes' band, two entirely new bands have made their appearance, and when the blood, saturated with the nitrous oxide, is then submitted to the action of reducing agents, the broad band of Stokes, as a reduction band, can no longer be produced at all, proving that a more permanent change has taken place in the vital chemistry of the blood.

"When a current of nitrous oxide gas is passed through a solution not made previously alkaline, still further changes take place. Here a portion of the nitrous oxide gas rapidly oxidizes at the expense of the oxygen of the blood, and forms hyponitric acid. Preyer holds that this hyponitric acid unites with the hæmato-cryst. of the blood in its nascent state. Like all acids, it alters and suspends the coagulability of the blood, and initiates other important chemical and optical changes. This event is marked by the appearance of an absorption in red to the left of D, from the 53° on Preyer's scale towards D, and another one between b and F. I look upon the appearance of this absorption in red as an indication that hyponitric acid has formed and has united with the blood. We already learned that all acids, cyanic acid excepted, causes a decomposition of the blood, and its product is hæmatine.

"Now let us logically apply all these ascertained facts to our case in hand, in order to learn how this gas produces its effects upon the economy.

"It deprives the blood of its oxygen, and enters into a close combination with its crystallizable material; so bound, it disables this latter to absorb oxygen from the air, or to supply it to the oxidizable tissues of the economy.

"In Preyer's experiments we have seen that the dogs, when permitted to inhale oxygen at the highest stage of the dyspnœa, they became rapidly as well as ever. Not so after the inhalation of nitrous oxide gas. A certain effect upon the blood has taken place, often unimportant and transient, at other times more permanent and grave, sufficient at times

to endanger life itself. We have also seen that under favorable conditions hyponitric acid is formed, which causes a decomposition of the hæmato-crystalline into hæmatine,—a substance which is not capable of sustaining life. Thus we are forced to acknowledge that the application of this gas is far from being safe and harmless; that on the contrary it is pregnant with grave consequences.

"Having fully pointed out to you the manner in which nitrous oxide gas affects the blood, it must serve you as a type for all those agents which deprive the blood of its oxygen, and form stable crystalline compounds with the hæmato-crystalline, whereby its life-function is gravely impaired, and under certain conditions forever lost.

"In case of accident with nitrous oxide our indications are confined to narrow limits. We must try to economize the still intact blood-corpuscles, and by transfusion, and especially by artificial respiration, to favor a full and long supply of oxygen to sustain the little flame of life. Electricity may be used to keep up the muscular action of the heart and lungs. We may thus succeed to ozonize the accumulated nitrous oxide, and to eliminate it from the system. Porowsky has thus succeeded in some almost hopeless cases of poisoning with carbonic oxide, and the procedure seems to me well adapted also in cases of poisoning with nitrous oxide gas."

Has the gentlemen proven the proposition he has started with? We think not. If experiments are carefully made and facts proven, we are bound to receive those facts, but not the theories in which he states that nitrous oxide gas "deprives the blood of its oxygen, and enters into a close combination with its crystallizable material; so bound, it disables this latter to absorb oxygen from the air, or to supply it to the oxidizable tissues of the economy." The following experiments were undertaken to prove or disprove the results Dr. Waterman describes as being obtained by the spectroscope.

René Benoit, of Montpellier,* gives the following results of his studies on transformations of the spectrums of the blood by alcohol, ether, chloroform, and sulphuret of car-

* Spectroscopic studies of the Blood—1868, p. 88.

bon:—"We know that alcohol coagulates the albuminoid substance of the blood. This change is probably not accompanied by any alteration of the coloring matter, because Valentin* has seen the characteristic bands in alcohol, which had been used for the preservation of anatomical preparations. In this case that matter had evidently not been dissolved, because when the globules of a pale rose in suspension in the liquid were in repose in the bottom of the vase, the bands disappeared even when the liquid still preserved a slight yellow tint. Ether, chloroform, sulphuret of carbon, alkaline salts, and neutral salts in general dissolve, but modify in no way the appearance of the spectrums of the blood."

The following experiments in the course of spectroscopic studies of the blood by the action of reagents were made by Professor J. G. Richardson, of the University of Pennsylvania, Dr. Wm. M. Hodges, of New York, Dr. C. S. Turnbull, of Philadelphia, and the writer.

Pigeon.—Respiration thirty-eight; pulse—unable to count—from one hundred and eighty-two to two hundred and ten. Was rendered insensible in twenty seconds, and had quite recovered in one minute.

Rabbit.—Blood identical with human blood under microspectroscope previous to nitrous oxide administration. Respiration one hundred and thirty-eight; pulse one hundred and sixty. Was affected in forty seconds, and completely insensible in two minutes. All heart action ceased in one minute and forty-five seconds. There was no change in the blood under the spectrum after death; little or no change in the brain; perhaps, slightly anæmic; heart's color natural.

Drs. L. Turnbull and Thomas took the gas, and their blood showed no change. By passing nitrous oxide through the blood, the death-line spoken of was barely visible, but after adding sulphide of ammonium it was clearly seen.

"From the above we may conclude," says Professor Richardson, "that the amount of pure nitrous oxide necessary to induce anæsthesia in man, by inhalation, does not

* Valentin: Der Gebrauch der Spectroskopes zur physiologischen und ärzlichen Zwecken, 1863.

so affect the blood as to cause any alteration of the two well-known bands in the green portion of the spectrum. In other words that the microspectroscope gives no evidence that radical change in the hæmato-crystalline is produced by the inhalation of nitrous oxide gas, such as that prepared by Dr. Thomas, of Philadelphia."

Dr. Taylor* states that spectral analysis has been applied to the examination of poisoned blood; but even this delicate method of research has failed to throw any satisfactory light on the changes produced by poisons in this liquid.

NITROUS OXIDE GAS IN DENTAL AND MINOR SURGERY.

For the use of the dentist and in minor operations, nothing has as yet been discovered offering the safety and other advantages which this gas possesses, administered directly from the gasometer. Since the introduction of a liquid form of nitrous oxide, one of the great drawbacks to its extended use has been done away with, as in this form it can be kept in iron cylinders for any length of time. When wanted the necessary quantity is allowed to pass in the bag carefully, avoiding the introduction of water or atmospheric air.

Dr. J. J. Colton † did much by his personal efforts and writings to popularize the use of nitrous oxide in dentistry, and it has been employed in Philadelphia by the Doctors Thomas in some *fifty-eight thousand four hundred* cases (since 1869), giving an average of nearly six thousand five hundred per year without a single death. Of this large number but very few cases exhibited unpleasant after-effects, not more than three in a thousand.

This accumulative evidence in our city alone is sufficient to prove, as I have before stated (see opt. cit., p. 242), that the inhalation of nitrous oxide does not produce pure asphyxia or entire privation of oxygen, but that it merely interferes in a more or less marked manner with the oxygenation of the blood, having also a *specific* action in its anæsthetic properties.

* On poisons, p. 63. Philadelphia, H. C. Lea.

† The Physiological Action of Nitrous Oxide Gas as shown by experiments upon man and the lower animals, together with suggestions as to its safety, uses and abuses. By J. J. Colton, A. M., M. D. Philadelphia: S. S. White, 1871, p. 32.

Nitrous oxide is not decomposed in the blood, nor does it form a chemical combination with it. Our own experiments and those of others have proven that it enters the blood in its pure state, and is eliminated in the same condition by the skin, kidneys, and lungs with only a diminution in quantity. It has no positive poisonous action on the blood-corpuscles, their color not being in the least altered under the microscope, nor does it cause any chemical decomposition. It does not produce death by preventing the escape of carbonic acid gas, for if the expired air, loaded with nitrous oxide, be passed into lime-water a carbonate of lime is precipitated.

It is, however, stated by some observers, that it combines with the hæmaglobin, and this is said to be proven by the spectroscope.

After numerous experiments and observations on man and animals, I have arrived at the following conclusions:—

1st. Nitrous oxide gas has a very limited range when given alone, owing to the rapidity of its action and still more rapid elimination.

2d. It acts directly upon the cerebrum and muscular apparatus almost simultaneously.

3d. It produces regular and progressive modificatian in the action of the heart and capillaries of the skin, and if carried to a greater extent it affects the spinal axis, and lastly the cerebellum and medulla oblongata with suspension of respiration, circulation, and, finally, death.

4th. Death in no case occurs without premonitory symptoms, and if respiration should cease for even a half to one minute, resuscitation is yet possible.

The rapidity of the pulse is generally increased, as shown by a record of one hundred cases taken and recorded by Dr. Thomas, it having reached as high as one hundred and forty-four in one case, and one hundred and twenty-eight in several others. In a few there was little or no change.

M. Paul Bert, who has perseveringly sought for a means of obtaining surgical anæsthesia which shall be effective and harmless, and who has already given the Society of Biology the results of his experiments upon the physiological action of protoxide of nitrogen, has tried substituting a mixture of this gas with oxygen, without compression, for

the ordinary pure gas. This mixture contained eighty-five parts of protoxide of nitrogen with fifteen parts of oxygen; a bird could live in this mixture forty-eight hours.

The first operation, for ingrowing nail, was performed by M. Léon Labbé. The patient was a girl aged twenty. She easily fell asleep, without any stage of excitement, she only presented some slight phenomena of contraction of muscles. The nail was extirpated without the patient making a movement. She awoke almost as soon as the mouthpiece of the inhaling apparatus was withdrawn. So far was she from being depressed, that she could walk at once, and asked to eat.—*Le Progres Medical*, 22 février, 1879.

In another case the patient was made to breathe not pure nitrous oxide, but a mixture of equal parts of nitrous oxide and air, under a pressure of two atmospheres. By this devise the normal quantity of air is supplied to the patient as well as the requisite dose of gas. The results obtained from experiments on dogs show that the breathing and circulation goes on normally while the animal is rendered quite insensible by this method, and on withdrawing the gas it recovers all its faculties after a few breaths. This is an important discovery, but it has the practical failing of, at present at least, requiring a special chamber to be constructed for the operation. In the case of hospitals, however, this will not be difficult to obtain.

DEATHS FROM THE INHALATION OF NITROUS OXIDE.

We only know of one instance in this city of supposed death from this anæsthetic agent, and in this case it was subsequently discovered that one of the cork props, which had no securing-string attached, was found at the *post mortem* examination in the larynx of the patient.

Second case.—In June, 1872, in the *Dental Cosmos*, was an editorial by James W. White, M. D., on a death alleged to have resulted from the inhalation of nitrous oxide gas administered by Dr. Newbrough, of New York, at whose office the death occurred, and by whom the following (summary) of evidence was made before the coroner's jury. The patient, a middle-aged lady, desired the extraction of seven or eight front teeth, which were *loose*. Dr. Newbrough

advised that their removal would be so easy that an anæsthetic would be unnecessary; but the patient insisted that she could not submit to the operation without it. Dr. Newbrough then procured a six-gallon bag of nitrous oxide gas; but the patient seemed equally fearful of anæsthesia as well as pain, and as soon as she made the inhalation, rejected the bag and declared her willingness to have the operation performed without it. At sight of the forceps her courage again failed her, and she decided once more to try the gas. She took one inhalation, and again rejected it. By this time so much of the gas had escaped from the bag that the doctor replenished it. Of this she took two inhalations, and peremptorily refused to have anything more to do with it, declaring her determination to submit to the operation. The teeth were then extracted. "Immediately," says the doctor, "she fainted; her head dropping over sideways." The face rapidly became livid, and, finally, purple; respiration falling to about fifteen per minute. In about *thirteen* minutes, notwithstanding the prompt application of the galvanic battery and efforts to assist respiration, death ensued.

Dr. Otis, summoned by Dr. Newbrough, arriving in about ten minutes after the fainting, testified that he continued the usual restorative treatment for *forty-five* minutes, when death ensued. At *post mortem*, found no disease of the heart; brain perfectly exsanguined in every part; no fluid in any of the ventricles; one lung was more engorged than the other, but healthy. As the testimony was very discordant in several particulars, we shall give only the conclusions of Dr. W., who carefully sifted the whole testimony:—

"In view of these discordant theories, it may seem presumptuous to express an opinion; but the conviction of the writer, based on personal experience, repeated hundreds of times, as well as on observation and reflection, is that nitrous oxide, when inhaled, acts primarily by a specific stimulant effect on the centres of innervation (over-stimulation and consequent depression, if continued), and secondarily by *preventing* the oxygenation of the blood."

The various opinions held by different observers doubtless owe much of their diversity to the considerations of the phenomena presenting at different stages of the toxical influence of the agent.

That the inhalation of nitrous oxide continued, produces by some method of action, no matter what its primary effect, progressive depression of vital functions, which tends to death, and in which the anæsthesia, or temporary unconsciousness sought, is a more or less clearly defined step in the downward path, there is no doubt.

Without discussing the processes of its manufacture, or the means by which its purity may be determined, or the best methods for its administration, suffice it to say, that immunity from danger can at the best be assured only by an intelligent and watchful guard, that its exhibition be suspended while yet the centres governing respiration and circulation are not too profoundly impressed.

Of the case under discussion, the inference seems entirely justified, that death was not caused by nitrous oxide gas, for the simple reason (if the evidence can be relied upon) that not enough was inhaled to produce such a result on any theory of its action. Nor was there any fact established by the *post mortem* to justify such a conclusion; while the testimony renders it entirely probable that the cause of death was nervous shock, from dread of pain and apprehension of fatal effect from the inhalation of an anæsthetic agent.

It may be remarked, however, that an examination by the coroner as to the possible lodgment of an extracted tooth in the air passages would have eliminated that from the list of uncertainties.

Death from Nitrous Oxide.—The following case is reported in the *Medical Times and Gazette* of April 7th. As it is of considerable importance, on account of the extended use of the anæsthetic, we quote it in full.

"An inquest was held last week, at Manchester, on the body of Mr. George Morley Harrison, aged fifty-three, a surgeon in good practice, and formerly lecturer on Medical Jurisprudence at the Manchester Royal School of Medicine, who died whilst under the influence of nitrous oxide gas, administered at his own request previous to having a tooth extracted by a neighboring dentist. Mr. Harrison, it appears, being unnerved and excited, partly from the suffering he had undergone, and partly owing to the want of proper food, which the condition of his mouth had prevented him from taking, insisted on the inhalation being pushed until

he should snore, and—for, at any rate, part of the time—held the mouth-piece in his own hand, and inspired very vigorously. The first attempt at extraction was made before he was fully insensible, and was abandoned until more of the gas had been given. Eventually, however, two teeth were removed. The patient did not appear to be coming round properly after the operation, and the dentist, taking alarm, sent for medical assistance. On the arrival of a surgeon, Mr. Harrison was pronounced to be quite dead. At the *post mortem* examination there was found some fat about the heart; the cavities on the right side were distended with blood, while those on the left side were empty. The lungs on both sides were gorged with dark blood. All the other organs were healthy.

"The jury came to the conclusion that the deceased 'died from syncope, during the administration of nitrous oxide gas for the extraction of teeth, whilst laboring under fatty degeneration of the heart.'"

*Post mortem in the above case of death from nitrous oxide.**—"The examination of the body took place seventeen hours after death. Rigor mortis was well marked, and there was considerable *post mortem* lividity. There was a good deal of fat beneath the skin, in the omentum, upon the external surface of the heart, and in the usual localities. The heart and pulmonary artery were opened *in situ*. The right side of the heart was distended with fluid blood; the left side was empty. There were two or three slight patches of atheroma in the aorta, and upon one of the aortic valves. There was some little evidence of fatty changes in the slightly altered color and consistence of the walls of the heart. The coronary arteries were examined and found free from disease. The mucous membrane lining the trachea and bronchi was congested. Some mucus was found in these tubes, but no blood or other foreign body. There was distinct thickening of the aryteno-epiglottidean folds and of the vocal cords. The lungs on both sides were gorged with dark fluid blood; at the left apex there was an old fibrous cicatrix. The liver was enlarged, its tissue was very friable, and of a dirty yellowish-white color. The kidneys

* Medical Times and Gazette, April 28th, 1877.

were full of blood; otherwise perfectly healthy. The bones of the skull were of unusual thickness. The visceral arachnoid was thickened and opaque. On removing the brain a large quantity of cerebro-spinal fluid made its escape, and the cornua of the ventricles were found dilated. The brain-substance was healthy, and its vessels full of blood."

In this sad case a most valuable life was sacrificed almost at the patient's own request. No man has any right to do as a patient desires, or allow him to be the judge of the quantity of an anæsthetic he should inhale, as a patient under such circumstances is not a competent judge.

The following are some observations of that veteran chloroformist, Mr. J. F. Clover, on this interesting case, addressed to the editor of the *British Medical Journal*:—

"SIR: In the *Times* of Good Friday last there appeared a notice taken from the *Manchester Examiner* of a death under nitrous oxide gas. The following was the verdict of the coroner's jury:—'Died from syncope, during the administration of nitrous oxide gas for the extraction of teeth, while laboring under fatty degeneration of the heart.'

"The details of so unusual an event would be highly interesting to the medical profession, to enable them to judge of the safety or danger of the anæsthetic used. To form a correct opinion, we should at least know how long the inhaler was applied, the order and manner in which the movements of the heart and respiration became affected, and what had been swallowed previously.

"The verdict was probably inaccurate in stating that the syncope occurred *during the administration* of the gas, as no symptoms of danger were noticed until after the extraction of the second tooth.

"The most probable explanation of this sad case is that the extractions were difficult, and that the patient, on recovering from the effect of the gas, was susceptible to the shock of a severe operation; and that this shock, and not the gas, was the cause of the syncope, which structural disease of the heart rendered fatal. Unfortunately, it appears that no third person was present, and we cannot expect the necessary evidence from the operator, whose attention was otherwise directed.

"Those whose opinions of the effects of nitrous oxide

are formed by inferences from Reid's *Experiments on Asphyxia*, and some cases of cardiac distress, first complained of after inhaling gas, will blame the latter. Those who daily witness the continuance of the circulation, in spite of the blood being black from the gas, and the cheerful and speedy reeovery from it, will conclude that so unusual a result must have depended upon the peculiarity of the patient, whose heart was found in a state sufficiently diseased to account for sudden death."

As this work was passing through the press, my attention was called to the fatal results following the inhalation of nitrous oxide in the case of Mr. Samuel P. Sears, the operator being Mr. José R. Brunct, D.D.S.*

A death from nitrous oxide occurred at Exeter, which we have before referred to. (See p. 166.) The gas was administered by Dr. F. F. Mason for the purpose of the painless extraction of a large upper molar tooth. The lady, Miss Wyndham, was about thirty-eight years of age, in good health. Her physician, Dr. Pattison, was present. Gas from the same source had been administered to other patients, so that its quality could not be impugned. She took the gas in the usual way, without any symptoms to excite uneasiness. At the proper degree of insensibility, the gas was stopped, and the tooth extracted. It was not until after the operation was completed that anything unusual happened; her face suddenly became livid, and the features began to swell, and she seemed to be quite unconscious. She breathed two or three times, and in a few moments her pulse ceased to beat. All attempts to restore her were fruitless.

"There was no obstruction to the air-passages, and the tongue was protruded, while she still respired."

So far as we have been informed, the medical profession of Philadelphia has never known of any injurious results from the inhalation of nitrous oxide gas.

Nitrous oxide is the safest of all anæsthetics. The statistics of the Colton Dental Association† claims to have anæs-

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* Dental Times, vol. i., page 157, New York, 1864. See also Instructions in Nitrous Oxide, by Geo. T. Barker, D.D.S., Phila., 1870, p. 56.

† The Relative Dangers of Anæsthesia, by E. Andrews, A.M., M.D., Professor of Surgery, Chicago Medical College. Chicago: Robert Fergus' Sons, 1870, page 12.

thetized about *seventy-five thousand patients* up to 1870 without any death. If the fifty-eight thousand four hundred cases (1869) of the Drs. Thomas is added, it makes *one hundred and thirty-three thousand four hundred up to* 1879, *and no deaths.*

THERAPEUTIC APPLICATION OF NITROUS OXIDE.

Neuralgia, uncomplicated, will sometimes be relieved by a few inhalations of nitrous oxide gas.

Nervous Aphonia.—This peculiar form of loss of the power over the voice, usually the result of hysteria, will be much improved by the patient inhaling a sufficient amount of the nitrous oxide gas to produce a partial loss of sensation and muscular relaxation.

Local paralyses have been benefited, where there was no brain lesion, by the gentle stimulation by the first stage of the gas, or the tingling and stimulating effect on the muscles.

Asthma.—This disease, when of a spasmodic character, is often much improved, by causing the patient to pass into the stage of relaxation, employing it every other day for a week or two.

Epilepsy.—When this disease is not the result of an organic change in the brain, spine, or other portion of the nervous system, but the result of some peripheral or reflex action, benefit will ensue by the use of the gas for weeks. It should be administered two or three times a week only, to produce the stimulating effects of the first stage of anæsthesia.

My friend, Dr. George J. Zigler,* has found the solution of the gas in water of much utility in disease of the lungs, kidneys, and other diseases of this class.

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* See his work on the subject.

CHAPTER VII.

Hydrate of Chloral. Chemical composition. Tests of purity from taste and odor. An abstract of original and selected observations on, and experiments with, Hydrate of Chloral on animals and man by the writer. M. Vulpian, injections into the veins. Physiological effects on man and animals. Dr. Bouchut on Hydrate of Chloral as an anæsthetic for children. M. Couty on death of animals from Hydrate of Chloral. Corroborative experiments by the writer. Prof. Oré of Bordeaux on intravenous injection of Chloral Hydrate. Advantages and risks by De Neffe, Van Wetter, Warlomont, Besnier and Vulpian. Cases of recovery from large doses of Hydrate of Chloral, and in certain cases death following moderate quantities. Delirium tremens produced by Chloral Hydrate. Case of Dr. Da Costa reported by Dr. Woodbury. Discussion on the subject of Chloral by members of the Philadelphia County Medical Society. Dr. Arbuckle's experiments with Chloral and with narcotics. Its influence on the retinal circulation. Chloral Hydrate—poisoning by, and means to prevent or treat. Therapeutic effects of Hydrate of Chloral on traumatic tetanus, nausea of pregnancy, eclampsia and convulsions, retention of urine, migraine, chorea, diphtheria. Local anæsthetic application and counter irritation with Hydrate of Chloral. Butylchloral-hydrate. Use of and experiments by Liebrech.

CHLORAL.—HYDRATE OF CHLORAL (C_2 HCl_3 O. H_2O).

Chloral (anhydrous) is a thin, oily liquid, but is rapidly converted into a white powder. It is produced by the action of dry chlorine on absolute alcohol, aldehyd and hydrochloric acid are formed, and by the continuous action of dry chlorine, a complicated reaction takes place, and chloral (trichloraldehyde) is found. The impure chloral is purified by distilling it with its weight of sulphuric acid (Squibb), combining the distillate partly with water, rectifying over a mixture of lime and calcium carbonate, and hydrating this second distillate by adding water. While hot, the mass is poured upon plates, covered with a bell-glass, and allowed to crystallize as pure hydrate of chloral. Chloral hydrate should be a white solid, never greenish, in crystals or flakes, or rhomboidal plates; taste like that of stale melon, pungent and disagreeable, with a chlorous odor, while that of the

impure is more pungent. It should dissolve with some difficulty in cold, but more freely in hot, water, requiring equal parts by weight for a perfect solution. If pure, the solution will keep for months, but if there are impurities, it soon becomes acid, and should not be employed. This is soon determined by litmus paper. The presence of hydrochloric acid may be detected by the addition of a few drops of sulphuric acid and solution of nitrate of silver. A white cloud will be formed should hydrochloric acid be present. The presence of organic materials in hydrate of chloral is detected by warming it with sulphuric acid, which acquires a brown color. At the present time impure chloral hydrate is manufactured at various parts in Europe and the United States, and is sold at prices to suit the individual. Chloral hydrate is readily purified by recrystallization from carbon disulphide.

Chloral hydrate which is not perfectly pure may sometimes be observed to become acid. This increase of acidity is not due to the decomposition of chloral hydrate itself, but to the decomposition of an accompanying impurity (chlorocarbonic acid), and sets free hydrochloric acid. When this occurs in the stomach it gives rise to great irritation, and when it occurs in the blood it causes great constitutional excitement, and is apt to produce nervous excitement, which state of excitation overcomes the hypnotic effects.

Owing to the excessive alkalinity of the blood in typhoid fever, ten grains of chloral hydrate will often suffice to produce hypnotic effects, while in the state of excitement of delirium tremens twenty to thirty grains are necessary; by hypodermic injection, fifteen grains.

The following conclusions are drawn from our experiments and observations, and after a perusal of the most recent literature upon this interesting subject.*

1. The physiological action of hydrate of chloral is to produce sleep, due to direct action of the drug upon the cerebrum.

2. Its symptoms are analogous to those produced by chloroform, but they are not identical.

* Original Observations and Experiments with Hydrate of Chloral, by Laurence Turnbull, M.D., Medical and Surgical Reporter, August 24, 1872, and August 31, 1872.

3. Only very large doses of chloral produce anæsthesia.

Dr. Amory, of Massachusetts, has proven that chloral hydrate does not decompose in the blood, and that its effects are not therefore due to chloroform. He was not able to detect chloroform in the blood exctrea, etc., of animals poisoned by chloral hydrate. These experiments have been confirmed by Lewisson and Rajewsky.

4. There are three degrees of the operation of chloral on animals and man, as shown by our own experiments.

The first degree is a feebly soporific, and slightly nervous sedative action.

The second degree is an intense soporific action, with diminution of sensibility. At this period there is a deep sleep of variable duration, without an apparent impairment of the principal functions of life, with great reduction of temperature of the whole body, but above all of the auditory canal.

The third degree is complete anæsthesia, with total loss of general sensibility and voluntary muscular power. Death may follow this degree of action, from interference with or arrest of the functions of the respiratory apparatus or heart, as was seen in our experiments upon animals.

5. Death takes place last at the heart.

6. In typhoid and typhus fevers we must commence and continue with small doses. Five grains is the average quantity required, to be repeated until sleep is induced.

7. It increases the flow of the menstrual fluid.

8. Large doses of the hydrate of chloral are apt to cause much disturbance of the stomach, and are therefore best given by the rectum.

9. In gout and rheumatism, chloral must be mixed with an excess of alkali, potassa or soda, to obtain the best results.

10. Males require a larger dose than females.

11. It is very valuable in diseases of little children, but care must be exercised to commence with small doses—gr. iji. for each month—and it should be mixed with nothing but water and simple syrup, as it is so apt to change and become worthless in contact with organic matter.

12. Hydrate of chloral will be found useful in phthisis, and even some forms of acute affections of the lungs, but not when the heart is involved.

13. It is a most valuable agent in nervous affections.

14. In affections of the eye its use requires care, as it causes swelling and redness and excessive flow of watery secretions, with obscuration of the vision and irritation of the retina. Dr. C. S. Turnbull has recently inquired into this subject, and after consulting intelligent inebriates, states as a fact that inveterate drinkers soon learn the deleterious effects of chloral hydrate upon their eyes, and plead for its omission in the soporific or stimulating substitutes prescribed for delirium tremens, etc.

15. In sunstroke or heat toxæmia, it is a most valuable aid to produce sleep in that restless state after reaction produced by frictions of ice and ice-water to the head and body.

16. In tetanus it has been found a most valuable agent in arresting the fearful paroxysms and giving the patient rest, and assisting materially to the cure, causing a relaxation to the affected muscles, and counteracting the effects of the spasm. It is best to administer it by the rectum, as the patient can rarely swallow on account of spasm.

17. In cases of impending death from poisonous doses of chloral, the system should be supported by heat, food, and artificial respiration, with stimulation and small doses of strychnia.

18. It has been found a most valuable agent in acute mania, combined with the bromide of potassium, and in the paralysis of the insane, dysmenorrhœa and tinnitus aurium.

19. Comparatively, trials prove it more valuable in maniacal cases in producing sleep than tincture of hyoscyamus or bromide of potassium, but it may advantageously be given with these agents.

20. Chloral is very useful in the convulsions of children (when there is no severe affection of the bronchi, heart, or lungs), but care must be employed not to administer it if the infant or child is very anæmic or in an exhausted condition, as in the case of a wasting disease.

21. The necropsy in case of death from hydrate of chloral shows anæmia of the brain, acute œdema of the lungs, hyperæmia of the abdominal organs, and dark fluid blood in the vessels.

22. Chloral hydrate has been found by us very useful in certain forms of asthma, given in a full dose during the

paroxysm, but not when there is feeble heart or emphysema of the lungs.

23. Chloral in weak solution is a useful antiseptic in removing odor and cleansing the ear in fetid otorrhœa, ulcers, etc.

CHLORAL AS AN ANÆSTHETIC.

If a solution of chloral be injected into the vein of a dog in a quantity sufficient to produce a profound sleep, complete anæsthesia is produced. The movements of the heart and of respiration continue. Occasionally, especially if the injection has been rapid, the respiratory movements suddenly cease, the heart continuing to beat for some minutes. Commonly the breathing recommences if artificial respiration is maintained for a few minutes, or if the trunk be faradized, intermittently, about twenty times a minute. It is sometimes necessary to continue this respiration for ten or twenty minutes before the spontaneous movements recommence. Occasionally this respiratory syncope, as it is termed by M. Vulpian, occurs only some time after the injection and during an experiment, perhaps in consequence of the traumatic irritation.

Another accident which may occur in dogs under the influence of chloral is the more or less sudden arrest of the heart's action, either during the intravenous injection or during an experiment involving irritation of the sensory nerves. The respiratory movements continue for some seconds after the heart ceases to beat. It is very rarely that the cardiac contraction can be restored by faradization employed at the moment at which the heart has ceased to beat. Cardiac syncope is certainly sometimes due to the reflex influence of nerves irritated during an operation, but occurs as a result of this irritation much more readily in animals under the influence of an anæsthetic than in those which are not, or which are under the influence of curara. The comparative immunity from this accident which is presented by curarised animals is no doubt to be attributed to the influence of the poison in moderating the action of the pneumogastrics upon the heart.

From the phenomena mentioned above, it is evident that

the respiratory centre suffers remarkably in animals under the influence of anæsthetics, and especially under that of chloral. A slight increase in the quantity of chloral in the circulation, or a reflex influence may arrest its action. So also with the cardiac centre. If the experiment of faradizing the pneumogastrics is repeated upon animals under the influence of chloral, it is found that the stimulation of the central ends of the divided nerves arrests the movements of respiration, just as in an animal of the same kind under normal conditions; but whereas in the latter the respiratory movements go on again spontaneously and easily in most cases, in spite of the continuance of the stimulation, they do not return spontaneously in dogs under the influence of chloral, and the animals die unless the faradization is stopped and artificial respiration employed, either alone or with the addition of intermitting faradization of the trunk. Sometimes a few seconds' faradization of the superior segments of the vagus nerve is sufficient to produce this arrest. Thus under these conditions we may have, on faradization of the central ends of the divided pneumogastrics, the same effect which M. Paul Bert has observed in animals not chloralized, sudden death. If the experiment is repeated in the same dog, the same result may be obtained two or three times, but no more. It is subsequently impossible thus to cause a persistent arrest of respiration. The spontaneous movements return after a suspension of a greater or less duration, although the faradization of the superior extremities of the vagi is continued. If in the same complete chloralization, the peripheral extremities of the pneumogastrics are faradized, the heart is arrested in diastole just as in animals under normal conditions, and, what is rarely observed otherwise, it may be permanently arrested if the stimulation is prolonged for a short time.

These experiments illustrate very strikingly the phenomena which are sometimes observed in man, and they are of especial value in their proof of the influence which traumatic irritation may have in arresting the action of a centre depressed by the influence of an anæsthetic. But the experiments stop just where we would like them to go on. The differences in this respect, if any, which are to be observed between ether and chloroform is a point of great

practical importance, and on which we hope M. Vulpian may be able to furnish us with further information.*

At the Medical Congress held at Brussels, in 1876, Dr. Bouchut observed that "he took that opportunity of again directing attention to the fact that children can be placed in a state of absolute anæsthesia by means of chloral given by the mouth in doses of three or four grammes, and without producing pyrosis, gastritis, vomiting or diarrhœa. It commences a quarter of an hour after the injection of the chloral, and is complete at the end of an hour. If at this period an abscess be opened, caustic applied, or a tooth extracted, the sleeping child may heave a sigh or move a limb, and again become immovable, waking up four hours afterwards quite unconscious of what has passed." This is a new proof of the difference which exists in the action of certain medicinal substances in adults and children.

Mr. Couty, of Paris, finds that when animals are killed by chloroform, ether, or chloral, the muscles and motor nerves retain their irritability much longer than when death is produced by bleeding, compression of the heart, or asphyxia. This is especially marked in the case of chloral. We have repeated these experiments with chloral on frogs, and showed the results before the Philadelphia County Medical Society, and published the results in the *Philadelphia Medical and Surgical Reporter*. Mr. Couty considers the cause of this phenomena to consist not on any action of the anæsthetics on the spinal chord, but in a direct modification of the nerves and muscles by them through the blood, similar to that which occurs in poisoning by carbonic oxide.

Prof. Oré, of Bordeaux, has introduced the intravenous injection of chloral as a means of producing general anæsthesia; he employs the following formula:—

℞.—Hydrate of Chloral, 10 grammes,
Distilled water, 30 grammes.

A graduated hypodermic syringe is employed, gold trocar and canula. A band is placed on the arm above the point selected, and when the vein has become prominent it is pierced through the skin, and fifty centigrammes are to be injected after removing the band. If anæsthesia is not produced, one gramme is added at a time until the patient

* London Lancet.

complains of a strong inclination to sleep, when the canula is withdrawn. From six to ten grammes are stated to be required for an adult. The author adds this caution: It is an indispensable precaution to have an electrical or galvanic apparatus at hand, in order to arouse the patient from his insensibility by passing a current along the course of the pneumogastric nerve. Advantages: Absence of stage of excitement, and of nausea and vomiting; accurate graduations of dose, absolute characters of the anæsthesia, muscular relaxation and prolonged blunting of the patient's sensibility, which protects him from shock. Risks: Thrombosis and embolism, irregularity of the heart's action, presence of blood and albumen in the urine, and above all, risk of fatal syncope and death.

At the seance of the Société Médicale des Hopitaux, held in June, 1874, M. Bacquoy reported a case of hydrophobia, in which he had exhibited the drug by this method; it produced profound slumber, and the patient awoke able to drink without spasms, but on the following day he died in the midst of a violent tetanic convulsion. The syringe contained one gramme of chloral dissolved in ten of water, and ten syringefuls were given in one hour and a half, followed by "chloroformic excitation." The injections were again repeated in one hour, thirteen grammes of chloral being injected.

At a late meeting of the Paris Academy of Sciences, M. Oré forwarded particulars of two fresh cases of anæsthesia produced by the intravenous injection of hydrate of chloral. In one case the object proposed was to scoop out the tibia on account of caries of the bone, the other was for the operation of ovariotomy. Anæsthesia in both cases was complete, and was neither accompanied nor followed by any accident which could be attributed to the chloral. M. Oré took the opportunity to point out the means of neutralizing the possible acidity of the chloral, a circumstance which might possibly bring on coagulation of the blood in the veins. For this purpose it is sufficient to dissolve one gramme of carbonate of soda in ten grammes of distilled water, and to add two or three drops of this solution to a solution of one gramme of chloral in four of water.*

* London Medical Record, January 6th, 1875.

The success which has attended a small series of some twenty cases of intravenous injection of chloral seems to have rendered some practitioners overbold; and the worst is that they do not always perceive the cause of fatal results when these have been produced. In a note to Professor Oré, of Bordeaux, the originator of this practice, Doctor Lande, relates a case of ovariotomy, in which sleep was induced in the space of thirteen minutes, after twenty-five grammes of an aqueous solution of chloral, containing five grammes of chloral, had been injected. The insensibility produced was absolute, and the operation, owing to adhesions which had to be ruptured with the hand, lasted about half an hour. The patient soon began to sink, and she died in little more than an hour after the operation had been commenced. There was a moderate amount of hemorrhage, which, in the anæmic condition of the patient, the reporter considers sufficient to account for death. Such a conclusion, however, M. Jeannel observes, reporting on the case in the *Union Medicale*, will certainly be disputed, since it is far more probable that death arose from the influence of the anæsthetic directly introduced into the circulation, the effects of which could be neither modified nor arrested. "The whole therapeutical history of chloral," he adds, "should teach us to employ it with the greatest caution."

Chloral hydrate has been found to produce in the hands of Jolly slight symptoms of vascular paralysis, and he recommends that these should be noted. It is, therefore, best to employ the remedy temporarily. He also takes note of the fact that habitual drinkers of chloral are now almost as frequently met with as opium and morphia eaters.

In the experiments of Dr. E. Mendel, of Berlin, it was found that doses of chloral hydrate sufficient to produce sleep reduced the temperature of the external auditory canal. Morphia has a like quality.

Oré was the first to inject chloral into the veins in tetanus; he suggests to use the same procedure as an anæsthetic in surgical operations. It is condemned by the learned societies of France as unwarrantably dangerous. Nevertheless, experiments were continued by Oré, De Neffe, and Van Wetter with good results, without any of the dreaded

dangerous consequences, such as embolism, phlebitis, hæmaturia.

Wartomont (*Des injections intra-veineuses de chloral comme agent d'anæthesie chirurgicale. Ann. d'ocul*) discusses the advantages and disadvantages of the injection of chloral into the veins, as an anæsthetic in surgery. His own experience extends to eleven successful cases. More than thirty are reported without an unfavorable result. "All roses, but thorns will follow." Among his observations are two on the eye; an enucleation, and an extraction of cataract, both with aged people (68 and 74 years). One of these cases was affected with chronic bronchitis and emphysematous lung, yet this condition was no obstacle to the successful result. The advantages of the anæsthesia by intra-venous injection of chloral are:—Prompt and positive effect; accuracy of the dose; anæsthesia is followed by a protracted, quiet sleep; absence of an exciting stage; absence of vomiting, and compatibility with derangement of respiratory organs.

The disadvantages are:—Difficulty of execution; necessity of utmost care and caution; the long duration of the effects of the application; possibility of embolism, phlebitis, hæmaturia, and intensity and long continuance of its effect, without the possibility of counteracting it.

Subcutaneous injections of chloral.—M. Besnier lays special stress on the necessity of burying the point of the needle in the subcutaneous tissue; he introduces the needle alone, watches it to see if any blood escapes (in which case he punctures in another place), and only finishes the operation when he is certain that the fluid will not be forced into a vein. In cases of sciatica, he injects on the first day one syringeful over the point of exit of the nerve, and another over the middle of its course. On the following day he makes another injection over the external poplitis. It is in tic douleureux, however, that he looks for the most valuable services from the injections.—*Lyon Med.*

M. Vulpian, in a communication made to the Acad. de Med. (June 2d), states that he has very frequently resorted to intra-venous injections of chloral as a means of producing anæsthesia in animals, so as to facilitate vivi-sections; and that very often in dogs hæmaturia resulted and there was

found very great renal congestion manifested by redness and ecchymoses in the substance of the kidney. He suspects the same effect might be induced in the human species, thus giving rise to lesions of the kidneys, which might become permanent, and, perhaps, result in Bright's disease. —(*Arch. Gen.*, July, 1874.)

CHLORAL HYDRATE.

Chloral hydrate has been employed in hundreds of thousands of cases by medical men without producing but very few deaths, yet in the hands of persons not in the profession several deaths have followed its indiscriminate use, or rather abuse. According to Dr. B. W. Richardson, the maximum dose is ninety grains, and with one hundred and forty the sleep would be dangerous. Yet deaths have been reported from sixty to one hundred, or even forty-five grains, but, as stated before, not ordered by a medical man, except in one or two instances. In recent cases reported by Mr. B. Browning, recovery took place after the use of one hundred grains, and as much as seven pounds has been used, in increasing doses, by one individual, without any very injurious results.

On the other hand, Dr. Fuller (*Lancet*, March, 1871) reports a case of death following the administration of thirty grains in a healthy young lady; and Dr. Schwaighofer, of Vienna, records (*Irish Hospital Gazette*, 1873) a similar result from the same dose in a drunkard. Dr. Dixon, of Springfield, Illinois, reports in the *Philadelphia Medical and Surgical Reporter* a case of delirium tremens, in which the patient took two hundred and forty grains of hydrate of chloral in three and a half hours with the most satisfactory results. Dr. Carroll, U. S. A., also reports, in the *Philadelphia Medical Times*, the death of a patient, who took, with suicidal intent, four hundred and eighty grains chloral hydrate.

The following interesting case of delirium tremens, under the care of Dr. Da Costa, was reported by Dr. Frank Woodbury*:—

"Mr. A., thirty-five years of age, American, a man of

* At a meeting of Philadelphia County Medical Society, April 10th, 1878, and published in Medical and Surgical Reporter.

fortune and indulgent in his habits, had been always a free liver. Without preparation, he was induced to absolutely resign all alcoholic stimulants. Shortly afterwards he sought medical adviee for sleeplessness and nervousness. He was ordered chloral, and found it very soothing in doses of twenty or thirty grains at night. Being pleased with the effect of the preseription, he discontinued his visits to Dr. Da Costa, and, of his own aceord, had the medicine repeatedly renewed, gradually inereasing the frequency and the amount of the dose, so that he eonstantly took from a drachm to a drachm and a half daily. He kept up this praetice for several months, all the time being free from medical supervision. Although he was remonstrated with by several members of his family on this new indulgenee, he considered the remedy not injurious to him, and as he liked the calming effects from it, he eould not be dissuaded from its use. After continuing the chloral thus for a period not short of four months, he lessened the dose, and then stopped rather abruptly. The consequence was that his weakened nervous system showed signs of great disturbance, and an attack of characteristic delirium tremens supervened, with the wildest faneies and great sleeplessness. The pulse was feeble and moderately aeeelerated; the first sound of the heart was weak. There was general prostration of the muscular system, and mueh tendency to sweating. No odor of chloroform was detected in his breath, and of eourse, no alcohol. He complained of nausea and loss of appetite; his tongue was coated. One of the prominent features in the case was a disposition to leave his bed and walk about the room, while the muscular weakness was strikingly shown in the fact that he was very soon fatigued. However, it required a man to watch over him eonstantly, to prevent his leaving the bed and trying to escape from his room. The ease perfectly reeovered, though slowly, under the use of small doses of morphine, a nourishing diet, and a moderate amount of alcoholic stimulants.

"It is not my intention to make any remarks upon this interesting case, but simply to present it in the hope of contrasting it with the experience of others. I may state, however, that a somewhat similar case of delirium tremens has been reported by Dr. Elliot (*Lancet*, 1853, 1, 751)."

On the other hand, Dr. Laurence Turnbull, in his recent work on Anæsthesia,* reports a case in which he "directed the employment of chloral hydrate in medicinal doses, for one year, as a sedative and narcotic, and the only disagreeable result complained of by the patient was that it caused a hot feeling, with free perspiration, as if she were in a hot bath. It was withdrawn at the end of that time without producing the least disturbance of the brain, inflammation of the skin, or loss of memory or intelligence;" and he inclines to the opinion that "other causes besides the hydrate of chloral may have produced some of the recorded results."

At a conversational meeting held at the Hall of the College of Physicians, Philadelphia, April 10th, 1878, the subject of "Chronic Chloral Poisoning" was discussed, and Dr. M. O'Hara recalled a case of chloral poisoning in a man occurring on one of the steamers while crossing the Atlantic. He was intemperate, and being unable to get his supply of alcohol, took to drinking chloral instead. The effects were very much like those of alcohol, as he had an attack of delirium tremens, which lasted for several days. There was no loss of muscular power in this case.

Dr. Bidlack had a case of nervous disorder, who took half an ounce of chloral hydrate during the night, using up four ounces in the course of one week, and absolutely without bad effects. Another case took it in ordinary doses for more than a year, without any but good results, but he has recently lost sight of the patient, and does not know of his present condition.

Dr. Benjamin Lee said that when chloral was first introduced, while it was still somewhat of a curiosity, he gave a mixture, containing ten grains to the ounce, to a lady just starting for the South, to relieve nervousness and inability to sleep. She took the first dose the night before sailing. He had given her very strict directions, cautioning her not to exceed the dose of five grains, as he had not then positively determined what the ordinary dose should be. Very shortly after her arrival at her home, he received letters from her telling of the delightful effects of the remedy.

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* Advantages and Accidents of Artificial Anæsthesia, by Laurence Turnbull, M.D., Philadelphia, 1877. Page 128, first edition.

She had voluntarily increased the dose, and was depending upon it. She returned as usual the following winter to Philadelphia, when he found that she was habitually taking from fifteen to twenty grains every night. As she was doing well in other respects, he did not consider it advisable to interfere immediately. At the end of eighteen months of the daily use of the chloral, probably never exceeding twenty grains in the twenty-four hours, she began to complain of conjunctivitis and smarting of the eyes. By advice the dose was diminished, when the irritation at once disappeared. He concluded that this conjestion of the palpebral conjunctiva was only one of the effects of the long-continued use of the remedy. After this she again passed from notice, and resumed the chloral in large doses. She again returned, complaining of pains in the wrists, located in the radial arteries, which was probably connected with a cardiac disturbance from the action of the remedy upon the unstriped muscular fibre of the heart. Upon discontinuing the chloral the pain in the wrists ceased. This was the second indication that the chloral was doing harm. The patient is still under observation.

Dr. Samuel R. Skillern had given large doses without bad results. One case in particular he recalled, where a hypnotic was needed to relieve restlessness accompanying paralysis following apoplexy. Less than one hundred and twenty to one hundred and thirty grains, in the course of the evening, would frequently have no effect whatever, and the patient must have averaged at least a drachm each night for nearly a year. The man finally died, but there was no evidence that chloral hastened his death.

Dr. W. R. D. Blackwood had a patient to whom he was giving chloral in half drachm doses, for the relief of neuralgia. For five months he has taken thirty grains three times daily, combined with bromide of potassium. For two weeks he took one drachm of chloral three times a day, and the only bad effect noticed was a conjunctivitis confined to the left side. The chloral was finally stopped abruptly, but no evil effects followed. There were no nervous symptoms, and no muscular tremors or weakness; in two days later he was able to walk down stairs.

Dr. James Collins spoke of a case that came under his care

in 1870. An old gentleman, suffering from chronic cystitis and enlarged prostate, obtained great benefit from one or two full doses of chloral daily. He was subject to suppression of urine, and at such times he complained of uncomfortable feelings after the medicine, with hot face, flushes of heat, etc., but as soon as the kidneys began to work this would pass away. The dose was increased to twenty-four grains. The speaker had used the drug frequently, but had never seen any bad effect when the kidneys were acting well.

Dr. Charles K. Mills believed that an explanation of the unsatisfactory results reported may be found in the fact that there are two classes of nervous cases; in one there is cerebral anemia, in the other congestion; in one the chloral does good, in the other not. He had found that where an idiosyncrasy against morphia existed, a previous dose of chloral would prevent any bad symptoms.

Dr. R. A. Cleeman reported a case where a dose of chloral always produced conjunctivitis in both eyes.

Dr. M. O'Hara recommended chloral as especially valuable in relieving the cough of phthisis, giving at a dose four grains of chloral with five drops of laudanum; and one drachm of syrup of lactucarium.

Dr. Laurence Turnbull thought that the chloral not only acted upon the conjunctival surface, but also upon the retina in certain cases, causing dimness of vision of a temporary character. This effect could be avoided, in his opinion, by combining with the chloral a salt of potassa. In diseases of the kidney it cannot be readily eliminated, and its effect is more marked and continuous. This may serve as an explanation of those cases where ordinary doses are followed by alarming symptoms.

THE USE OF CHLORAL IN ALCOHOLISM.

Dr. Fürstner, of Vienna, is quoted by the London *Medical Record*, on this subject, as follows:—

"In the first published cases of delirium tremens treated by chloral, its favorable action was not always very marked; sometimes its effect was temporary, sometimes altogether absent; in some of the cases toxic symptoms were caused, and it soon became evident that the dose necessary to produce the desired result varied within very wide limits. It must never

be forgotten that many patients, when they first come under treatment, still have a large quantity of uneliminated alcohol in the system. Though the general symptoms of depression, caused by large doses of alcohol, are often not very marked in habitual topers, still the condition of the pulse deserves the most careful consideration in deciding the dose of chloral to be given. Certain patients, not necessarily weak and emaciated, but apparently robust, muscular persons, often have a remarkably small, frequent, compressible, occasionally irregular pulse, with great faintness of the heart sounds, and a less degree of motor restlessness than usual. The author has repeatedly satisfied himself by necropsies that these symotoms are not due to any disease of the heart; they must, therefore, have a central cause. Having regard to the facts that chloral has been proved experimentally to have, in large doses, a paralyzing action on the heart and vaso-motor centres, and that several published cases show that chloral has had a pernicious effect in alcoholism, it is necessary to be most careful in the administration of chloral in the cases just described. The author believes that cases of sudden death in delirium tremens, after the administration of chloral, are to be explained by the combined cumulative action of alcohol and chloral upon the vital centres in the medulla. It may be urged against this theory that sudden death is by no means uncommon in this disease, even when no chloral has been given; Dr. Fürstner believes that in these cases the alcohol has, of itself, been sufficient to stay the functional activity of the vital centres; it is, therefore, most important not to increase this danger when it threatens, by administering chloral. All patients who, though apparently robust, have the small, frequent and compressible pulse described above, without other complications, are treated by Fürstner without chloral; they are secluded if they cannot be kept in a general ward, and small doses of wine and spirits are given with good results.

INFLUENCE OF CHLORAL HYDRATE ON THE CIRCULATION OF THE FUNDUS OF THE EYE.

Dr. I. H. Arbuckle (*West Riding, England, Lunatic Asylum Reports*,* vol. v.) finds that the following substances—

* Quoted by Ringer, Handbook of Therapeutics, page 334.

nicotia, atropia, hyoscyamia, aconitia, nitrite of amyl, prussic acid, strychnia, morphia, picrotoxine, hydrate of chloral —pushed even to a fatal dose, do not in any way affect the circulation of the fundus of the eye. His observations were made on rabbits, and the results he obtained were, with respect to some of these agents, confirmed by experiments on man. Hence the statement, hitherto generally received, that, the retinal circulation corresponds with the cerebral circulation, changes in one always implying changes in the other, must be accepted with caution.

POISONING BY HYDRATE OF CHLORAL AND ITS TREATMENT.

In a case seen recently by Dr. J. Milner Fothergill, of London, of complex lung and heart mischief, to which was added chloral poisoning, the good effects of strychnia, confirming Dr. Liebreich's observations, were well marked. The patient was almost at once relieved from the attack of dyspnœa, in the middle of the night, to which he had long been subject. By the use of strychnia during the day, a narcotic pill at bed-time is often deprived of its tendency to produce nocturnal dyspnœa. We might add that strychnia, in combination with ammonia and senega, might be found very useful in the after-treatment of congestion of the lungs, from the excessive use of sulphuric ether and alcohol; it is surely worthy of trial.

Hydrate of chloral, when given in large doses, sometimes causes dangerous symptoms, followed by sudden death. Several instances are recorded of medical men who have taken it incautiously, and have died from its effects; two cases are reported in the *Medical Times and Gazette*, 1871, vol. i, p. 367, and of late they have become numerous. The deaths have been sudden, and no remarkable symptoms have preceded dissolution, as observed by Dr. Taylor. The person has passed at once from sleep into death. One case proved suddenly fatal by causing paralysis of the heart (*Lancet*, 1871, vol. i, p. 440). "In the fatal cases which have occurred, the principal *appearances* noted were congested state of the brain and its membranes." Doctors Taylor and Tuke have given it as their opinion, based upon *one* case, that the long-continued use of chloral might have produced

a diseased condition of the brain, which, by the sudden withdrawal of the narcotic, might have caused the accusation of murder (a man in a fit of passion, for some trivial cause throws a petroleum lamp at his wife, which ignites her dress, and death is the result, by burning). I have directed the employment of chloral hydrate in solution in medicinal doses for one year as a sedative and narcotic, and the only disagreeable result complained of by the patient was that it caused a hot feeling, with free perspiration, as if she were in a hot bath; it was withdrawn at the end of that time without producing the least disturbance of the brain, inflammation of the skin, or loss of memory or intelligence. We have had no fatal cases, therefore, I believe that other causes besides the hydrate of chloral may have produced some of the recorded results.

In the treatment of poisonous doses of the hydrate of chloral the stomach-pump should be used, and the stomach well washed out with a decoction of green tea. The same treatment as for poisoning by opium is indicated, *i. e.*, employ the physiological antidotes, such as atropia and strychnia in hypodermic injections of the $\frac{1}{120}$ to $\frac{1}{30}$ of a grain. Maintain artificial respiration for several hours. If necessary, employ the galvanic or faradayic current. Administer for six or seven hours brandy and beef tea, in mucilage of gum acacia, per rectum. When consciousness returns, keep the patient moving, and apply flagellations and frictions to the body. When able to swallow give brandy, beef tea, coffee, effervescing drinks. The patient must be closely watched by an attendant.

In cases of chronic poisoning by chloral:—First apply warmth, and furnish warm air. Second, sustain the body by an abundance of food, especially warm milk, with a little lime-water, and stimulants, say every two or three hours, one or two ounces of brandy or whiskey to half a pint.

THERAPEUTIC EFFECTS OF HYDRATE OF CHLORAL.

Chloral in Traumatic Tetanus.—Chloral has been found to be exceedingly valuable in relieving and curing cases of tetanus and trismus. There have been, up to June, 1879, forty-one cases of tetanus treated by this agent, in which there has been twenty-six recoveries, and fifteen deaths.

No.	Reported By	Mode of Treatment.	Whole No.	Died.	Recovered.
1	W. B. Cluness	Chloral alone	1		1
2	M. Verneuil	Chloral alone	1		1
3, 4	MM. Dubreuil, Lavaux, and Onimus	Chloral and continuous current.	2		2
5	Dr. Dufour	Chloral alone	1		1
6	M. Guyon	Chloral alone	1	1	
7	M. Le Fort	Chloral alone	1	1	
8	Mr. Tay	Chloral alone	1	1	
9	E. R. Denton	Chloral, belladonna, and potas. bromid	1		1
10	Thos. G. Duncan	Chloral and Calabar bean	1		1
11	Preston Peter	Chloral and Calabar bean	1	1	
12	John W. Ogle	Chloral, belladonna, and ice to spine	1		1
13	Mr. Croft	Chloral alone	1		1
14	Mr. Paget	Chloral alone	1	1	
15	J. Suydam Knox	Chloral alone	1		1
16 to 22	C. Macnamara	Chloral alone	7	6	1
23, 24	M. Garnies	Chloral alone	2		2
25 to 34	Dr. Widerhofer	Chloral alone	10	4	6
35	F. Auchenthaler	Chloral alone	1		1
36	Dr. Beck*	Chloral alone	1		1
37	Dr. R. J. Levis	Chloral alone	1		1
38	Dr. Wm. Hunt	Chloral alone	1		1
39	Dr. J. C. Ross	Chloral alone	1		1
40	Dr. Velaplana	Chloral alone	1		1
41	Dr. H. G. Below	Chloral alone	1		1
			41	15	26

Dr. O. Liebreich† states that chloral does not act by removing the cause of tetanus, but simply by counteracting its effects, and that its use must therefore be persisted in, so long as the muscular spasm continues to recur.

Chloral hydrate in obstinate vomiting of pregnancy.—Dr. H. J. Robinson, of Jacksonville, Florida, writes to a friend of mine that he has used with success hydrate of chloral in two drachm doses, and repeated in an hour or two if necessary, in obstinate vomiting of pregnancy when the stomach ejected everything, and sleep was almost impossible. It furnished relief and sleep for four to six hours, and was gratefully appreciated. It could be mixed with starch or gum water, so as to not irritate the living membrane of the bowels.

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* Table in part compiled by Dr. Joseph R. Beck, Fort Wayne, Indiana.

† Berliner Wochenschrift, No. 13, 1870.

Chloral in Eclampsia.—Dr. J. Masten,* of Whitfield, Pennsylvania, reports a case of eclampsia succesfully treated with chloral hypodermically. He remarks:—

"I found my patient with strong convulsive movements of the facial muscles and muscles of the extremities, and was informed by her attendants that this was the second, and a very severe convulsion. Failing to procure either chloroform or ether, I felt that I was in very close quarters, with a responsible and dangerous case on my hands, and that the pulse, which was very weak and fluttering, forbade the use of the lancet.

"Being thrown entirely upon my own resources, and considering myself justified in using any remedy that offered a hope of success, I immediately dissolved what I judged to be ten grains of chloral hydrate in a small quantity of water, and injected it subcutaneously in the left leg. The convulsive movements soon ceased, and I was gratified beyond expression to see my patient begin to rally, although nearly half an hour passed before she could control the muscles of deglutition, after which I administered the chloral, in combination with bromide of potash, about ten grains each, every hour. There was complete blindness for over an hour, but no symptoms of a return of the convulsions until seven a. m., of the 24th. She then informed me that the pain in her stomach was returning, and that she was getting blind again, precursor to a third convulsion. I commenced crowding the chloral and bromide, and the attack was warded off.

"There was no return of the convulsions, nor any symptoms, after this period. It was not until three days after confinement that she realized that her labor had taken place. I saw the patient on the second day of June, and found her getting along fully as well as in previous confinements.

I attribute the good results in this case to the prompt administration of the chloral hypodermically. I was unable to examine the urine for albumen, from the fact that, from the first convulsion until forty-eight hours after, there was complete suppression of urine."

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* Medical and Surgical Reporter.

This agent has been found useful in all general convulsions and spasmodic diseases, which depend on direct disturbance of the central nervous system, but is contra-indicated in hysterical convulsions, owing to the initial excitement which is so often present. It is best to avoid it also, or give it with great caution, in ulcerations of the *primæ viæ*, in gouty states, in typhoid fever (see our experiments), and in disturbances of the circulation. (Liebreich.) Chloral hydrate should be given with great caution to patients with cardiac disease. (Rosenstein.)

Fothergill points out the fact that in an anæmic condition of the nervous centres chloral is contra-indicated; and Da Costa advises caution in its administration, and remarks that "in eases of cardiac debility, and in dilation, or much obstruction of the heart, it is generally contra-indicated."

A distinguished alienist, Dr. Given, who has a private institution ("Burn-brae," Clifton, Delaware Co., Pa.) for the treatment of the insane, informs the writer that chloral hydrate has been found by him very valuable in various forms of insanity in procuring sleep and allaying nervous agitation.

Dr. Kerlin, chief physician of the Training School for Feeble-Minded Children, at Media, Delaware Co., Pa., combines the chloral with bromide of potassium in chorea, epilepsy, and various forms of nervous disturbance in children, with the most happy results,—*i.e.*, in procuring refreshing sleep.

Retention of urine relieved by Chloral—Dr. Tidd reports the case of a young woman, in the ninth month of pregnancy, who had not urinated for twenty-four hours, as a result of which the bladder was enormously distended. Catheterization was tried, but failed, in consequence of the swelling and of the deviation of the urethra. Puncture of the bladder was proposed, but the patient refused to consent to it. Ten grains of chloral were then ordered every half-hour. It produced a deep sleep, during which the patient passed unconsciously an enormous quantity of urine. The evacuation commenced five minutes after the second dose of the solution. The retention did not return, and seven days later the patient was delivered of a healthy child.—*Jour. de Med. de Bordeaux.*

Chloral in Migraine.—Dr. Seure, in the *Bull de Therapeu-*

tique, strongly recommends the administration of chloral in enema, on the occurrence of the paroxysms of migraine, having found it almost infallible, and exempt from the disadvantages attendant on other modes of giving this substance, and far preferable to the employment of morphia, quinine, etc., for the same purpose. He gives, according to the sex or robustness of the patient, from one and a half to three grammes in a glass of tepid water, the effect of the chloral being rendered still more prompt by the addition of a tablespoonful of brandy. If a sense of burning in the rectum is excited, this may be prevented by adding the yolk of an egg, or by substituting tepid milk for the water. When, as in some persons, there is difficulty in retaining the enemata, the quantity of the liquid may be diminished, and a drop or two of laudanum added.

Chloral Hydrate in Chorea.—In the treatment of chorea sleep is of the first importance, and it should be quiet and long-continued. According to the most recent experience, hydrate of chloral has proved an extraordinarily valuable remedy in the treatment of chorea, especially in cases where the violence of the jerkings interferes with sleep, or the sleep is itself disturbed by spasms at night. If the intensity of the movements exhaust the patient at night, it is well to give a dose or two during the day, in order to secure a few hours of sleep. This usually comes very speedily, and the muscular disturbance is soon quieted.

In conjunction with this remedy our best authorities advise full doses of Fowler's solution of arsenic. For many years it has been given with the best effect and with no bad consequences, double the doses mentioned in the text-books —namely, from five to eight drops of Fowler's arsenical solution for children from eight to ten years old, and from eight to twelve drops for adults, three times a day. It is best to give this preparation not by drops, but mixed with aromatic water and syrup.

Hypnotics and anæsthetics may be entirely dispensed with in slight and moderate cases of chorea, but they are of great value in extreme cases, where the excessive muscular restlessness and sleeplessness threaten to exhaust the organism. Von Ziemssen* decidedly prefers chloral hydrate; it almost

* Practice of Medicine. Ziemssen.

always acts promptly and surely. By day or night a dose of from fifteen to eighty grains is followed by quiet sleep and cessation of the muscular activity.

Other authors have recommended chloral hydrate in severe cases, as "Frerichs," "Gairdner," "J. Russel," "Bouchut and Verdalle."

"Gairdner" saw a case of chorea in a girl of eight years, who took by mistake a dose of sixty instead of thirty grains of chloral hydrate, and after recovery from her intoxication was found to have entirely lost her chorea. "Frerichs" gave it in the dose of eighty grains to a male of seventeen years with severe chorea. The result was a refreshing sleep of five hours. "Russell" obtained good results in the fifth month of pregnancy, after bromide of potassium had been given in large doses without success. "Bouchut's" patient of fourteen and a half years, with chorea and dementia, took forty-five grains a day for twenty-seven days, making in all somewhat over two and a half ounces, spent almost the whole time in sleep, and suffered no visible bad results from the chloral. Improvement appeared from the fifth day of the use of the chloral, and the case was complete on the twenty-eighth day. "Verdalle's" patient of eleven took very nearly three ounces in fifteen days. The improvement began to appear on the first day the medicine was given, or the fourteenth of the disease. In certain forms of chorea, either associated with or depending upon a rheumatism or tuberculosis, benefits have been derived by associating the hydrate of chloral with actecca racemossa in the form of tincture, fifteen mimims *ter a die.*

Chorea treated successfully by injections of hydrate of chloral, by Drs. Goltz and Auger, after eserine and subcutaneous injections of morphia had been tried.—This drug cannot be employed subcutaneously, owing to its tendency to produce local irritation, whilst when given in the form of mixture or syrup it occasions nausea. When introduced into the large intestines it does not produce any remarkable sensation of burning, or any secondary symptoms. They commenced with the administration of forty-five grains of chloral twice a day in the form of enemata. Only slight improvement occurred at first, and they increased the dose to sixty grains twice a day. Under this treatment, complete recov-

ery, which was not followed by any relapse, took place in fifteen days.*

Use of Chloral in Diphtheria.—Dr. Rokitansky (*Medicinische-Chirurgische Randschau*, November, 1878) has used fifty per cent. solution of chloral in three cases of diphtheria which had resisted the usual remedies, such as salicylic acid, carbolic acid, etc., and every time with the same results. The solution was applied every half hour with a camel's hair brush, and caused but very little pain except in one case, where the tongue was thickly covered with a layer of diphtheretic matter.

After the solution had been applied three times,—*i.e.*, one hour and a half after the first application—large pieces of membrane could be easily removed with the brush. The underlying portion of the mucous membrane was red, and covered with fine granulations. As soon as the normal tissue could be seen, weaker solutions of chloral were gradually used, during the week, at the end of which the patients entirely recovered.—*London Medical Record* December 15, 1878.

LOCAL ANÆSTHETIC APPLICATION OF HYDRATE OF CHLORAL.

Camphor and chloral when mixed in equal parts form a thick oleaginous and transparent liquid which, according to Prof. Howell of this city, is one of the best local anæsthetics he has ever employed. I have made this beautiful preparation, and have made numerous satisfactory experiments with it in relieving pain when applied locally.

Dr. Wm. J. Tocher recommends the following for a camphor-chloral liniment, which has a powerful anti-neuralgic action: Chloral hydrate and camphor, of each one ounce; glycerine six ounces. Powder the camphor, using a few drops of rectified spirits, mix with the chloral and allow to stand until the mixture becomes liquid, adding glycerine.†

CHLORAL AS A COUNTER-IRRITANT.

Among the many uses to which chloral has been put, we have not met before with the following from the *Bulletin*

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* Practioner, December, 1876.

† London Medical Record, January 15th, 1878.

Therapeutique: Made into a mass with gum tragacanth, spread on a paper and applied to the skin, it will produce a blister without pain; applied as powder on cotton, it causes a painful burning sensation. By the former method a portion is absorbed and the patient falls asleep. Its action is not so uniform as cantharides, but as a mild visicant, or an agreeable revulsive, the writer would recommend such chloral paper to physicians, the more so as it will keep for months without losing its activity, if well prepared.

BUTYLCHLORAL HYDRATE.

When I described this agent in my first edition, it was termed *croton-chloral*, but since (1875) it has been determined that it is *trichlorbutylaldehyd*, which is butylaldehyd C_4H_8O, with 3H replaced by 3Cl. The hydrate contains a little over nine per cent. of water. It is prepared by passing chlorine gas into acetic aldehyd placed in a refrigerating mixture, dissolving the dry mass, after distillation, in hot water, allowing it to crystallize. It crystallizes from the water in thin white scales of a silky lustre, is freely soluble in alcohol and hot water, but not soluble in cold water. The alkalies decompose it.

Administered to animals, it produces anæsthesia with some degree of excitement. If the dose be large, it destroys the animal by arresting the action of the heart. In man it produces anæsthesia, sleep, and relief of pain in doses of from ten to thirty grains, the sensibility of the skin of the face being first affected, and then the lower extremities, followed by sleep which is deep and lasting, if not disturbed, for two hours.

Its taste is like chloral hydrate, acid and disagreeable, leaving its impression on the throat, and is not to be disguised. It has received a reputation for the cure of neuralgia of the fifth pair, and especially in that most painful form, tic douloureux. It has no advantages in other forms of neuralgia, insomnia, nervous headache, or as a palliative in dysmenorrhœal neuralgia over the hydrate of chloral. It is very difficult to obtain it pure. By some good authorities it is stated to be entirely unsatisfactory in its results, having produced in their hands excitement, irritation of the throat, nausea, and vomiting.

Dr. Oscar Liebreich, who introduced this valuable agent into the service of medicine, has made a series of experiments with butylchloral upon rabbits and the human subject, which are reported in the *Centralbl. f. d. Med. Wissensch.* This distinguished authority found that in animals it produced anæsthesia of the head without loss of sensibility of the rest of the body; and in man anæsthesia of the fifth nerve only.

To a child aged four and a half years, after trials had been made with smaller doses, 2.5 grm. of butychloral were given in sweetened water. It soon fell into a sleep, from which it could be aroused by pinching its arms, falling again into slumber as soon as the irritation ceased. Irritation of the cornea, however, had no effect, and it appeared to be entirely without sensation. This want of sensibility was noticed even when the child was roused from sleep; but the nasal mucous membrane, on the other hand, was sensitive. To lunatics five grm. were given, and sleep, with anæsthesia, produced while the patients remained seated upon their chairs, to such an extent were the sensibility and reflex irritability of the body maintained. Contrary to expectation, this remedy has afforded but slight relief in cases of tic douloureux, but he recommends it as affording temporary relief in trigemminal neuralgia.

In the transactions of Medical Society of the State of Pennsylvania, vol. xii, part i, 1878, in the report of Committee of Revision of the U. S. Pharmacopœa, "Croton Chloral" through Dr. H. H. Smith, was not recommended for introduction into the list of therapeutic agents. We are of the opinion that "croton chloral" has been hastily denounced because most of the drug used must have been impure to have caused all that is charged against it.

Ringer* says croton chloral is, perhaps, the most efficacious remedy in facial neuralgia. In neuralgia due to carious teeth, in facial neuralgia in old people, in whom the disease is most obstinate and severe, it is alike beneficial.

* Hand book of therapeutics, Ringer, 1879.

CHAPTER VIII.

Inhalers of Hawksley, Hearn, Cheatham, Lente, Allis, Morgan, Richardson, Angrove, and Clover for ether. Inhalers of Allis and Skinner for chloroform. Inhaler of Thomas for nitrous oxide gas. Inhalers of J. F. Clover, F. R. C. S., and Codman & Shurtleff for nitrous oxide gas and ether. Bonwill method of anæsthesia by rapid respirations.

Most of the inhalers in use are made with the object of heating the anæsthetic used, to furnish a large evaporating surface or to serve the purpose of allowing an admixture of atmospheric air with the gas or liquid to be inhaled.

HAWKSLEY INHALER.

It consists of "a glass vessel capable of holding ten ounces of ether, with an inlet valve for air, and its sliding tube is graduated in ounces for the purpose of measuring the quantity of ether consumed. A pipe conveys the vapor to the face-piece, the edge of which is surrounded by a water cushion to secure exact adaptation. There is also a shutter valve for regulating the admission of air, either at the beginning of an operation or during its course. It has also an additional pipe, furnished with a valve, which conveys the expired vapor to the floor." This latter is a useful addition, when employed in a hospital where a large number of patients are to be etherized in succession, so that the ether is not diffused in the air around the operator. When in use, the vessel in which the ether is contained is immersed in water, heated to 100°, which promotes a more rapid and equable evaporation of the ether. "Ether boils at about 90°; but before the quantity contained in the vessel has reached that point, the temperature of the surrounding water will have fallen." This is a valuable inhaler; it is too complicated for every-day use by the physician or surgeon, but will be found very useful in large hospitals, and cause a great saving in the amount of ether employed.

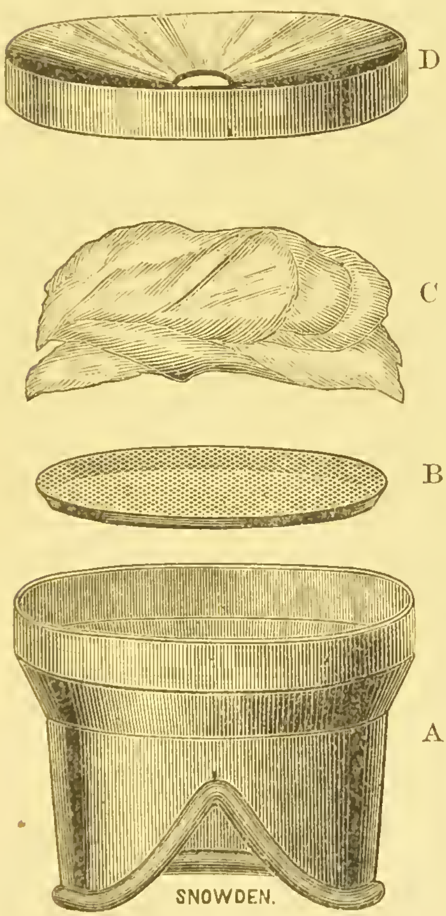
In the most recent ether inhaler invented by a gentleman

of great practical experience, it has two most positive advantages; there is no waste of ether or diffusion in the room; second, the cloth can be removed and the water pressed out of it, and again employed, being free from all moisture and carbonic acid.

HEARN'S ETHER INHALER

Is named after its inventor, Dr. Joseph W. Hearn, of this city, who has had an extended experience in the administration of anæsthetics.

Fig. 15.



The inhaler, Fig. 15, has its outer case A made of thin sheet metal, having the lower edge, which comes in contact with the face, covered with rubber.

Inside of this case a screen of wire gauze B is fitted, which comes opposite the lower joint, as at A.

The lint or canton flannel upon which the ether is poured is shown at C, and is held in place between the wire gauze screen B and the funnel shaped top D.

The object of this inhaler is to furnish an undiluted ether vapor, and prevent, as it should when ether is used, the patients inhaling the surrounding atmosphere. The time required to produce complete anæsthesia, in ordinary cases, is from five to eight minutes.

"Another object of the inhaler is economy; it rarely re-

quiring more than two or three ounces of ether to produce the full effect, for which reason it is especially adapted to hospital use. The apparatus, by confining the ether vapor, prevents in a great degree the impregnation of the atmosphere in the room." If the patient needs air the inhaler can be withdrawn between every second or third inspiration.

Almost all American surgeons employ ether in the various operations, even for the most delicate, viz., on the eye and ear. In Great Britain and Ireland, the surgeons for a time employed chloroform to the almost entire exclusion of ether, but within the last few years the subject of the greater danger in the use of chloroform has excited much attention, and many of them have changed their views, especially since the visit of Dr. B. J. Jeffries, of Boston, Massachusetts.

CHEATHAM'S ETHER INHALER.

This operates by replenishing the evaporating surface without removing it from the face. A patient cannot be etherized as quickly with it as with the common cone, but with much less ether, and by it you avoid the disagreeable effects of having the ether permeating every part of the office or house in which it is used. Its convenience of application is also quite obvious. The ease with which the face-piece (being paper) can be removed immediately after use and thrown away is, I think, a strong recommendation in its favor.

The apparatus consists of a tin cup (Fig. 16, A) holding in

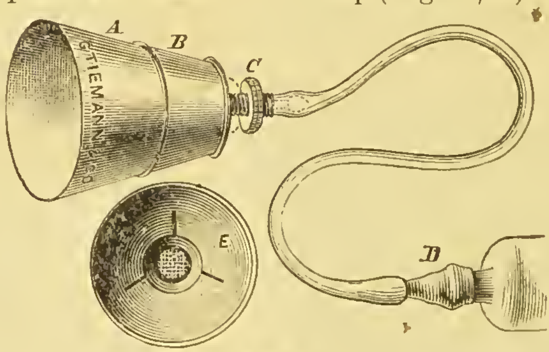


Fig. 16.

the inside a sponge as an evaporating surface, and connected from the top by rubber tubing with the bottle that contains the anæsthetic. This tube has attached to its dis-

tal end a cap D, that will fit over the neck of almost any bottle, thus doing away with Lente's graduated bottle.

Mode of using the Inhaler.—Make a cone of paper, cut the top off, so when the tin cup, A, is slipped inside the top of the cup it will protrude a line or two from the top of cone. Place tin cup, B, over both cup and cone, screw it down tightly by means of nut, C, and you have the cone held tightly. Attach tube to top of cup, and the apparatus is complete. The smaller the cone, the more quickly you can get the patient under the influence of the anæsthetic. I would suggest after the cone is in position, the bottom should be trimmed, leaving a part of it (we shall call it the back part) that is intended to go over the chin, three inches longer than the cup, and sloping forwards and upwards, leaving the front part, intended to go over the nose, about an inch longer than cup. E gives an inside view of cup, A.*

DR. LENTE'S ETHER INHALER.

As early as 1866, Dr. Lente invented a form of inhaler, but which has recently been modified. See Fig. 17. The present improved instrument resembles very much the face-piece of "Waldenburg's apparatus for the inhalation of condensed and rarefied air. The idea of using sheet brass and the india-rubber air-cushion was taken from it. The air-cushion, however, proved a failure, and the inventor substituted hair for stuffing the cushion, which he states retains sufficient of its rotundity to fit the face air-tight.

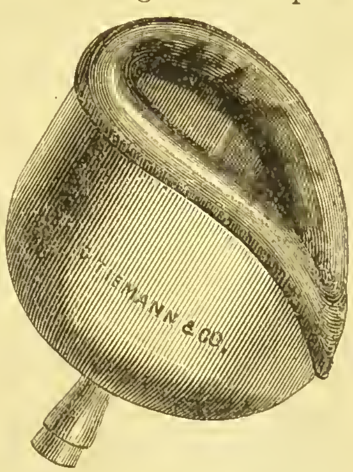


Fig. 17.

Mode of employing this form of Inhaler.—A piece of sheet lint is stuffed into the cone, a piece of wire or whalebone is slipped in, so as to keep the lint in place and prevent its touching the face. The lint is

* These various forms of Inhalers are made by S. S. White, Snowden, Gemrig, or Kolbe, instrument makers, of this city; also, George Tiemann & Co., of New York, and by Codman & Shurtliff, of Boston.

saturated with ether and placed over the face. There is an opening, fitted with a cork stopper at the apex, large enough to admit air. This is usually closed, but if it is found necessary, the stopper can be removed. The ether can be poured in at this opening without removing the apparatus from the patient's face. Its cleanliness is perfect, as a different piece of lint ought to be employed each time.

ALLIS' IMPROVED ETHER INHALER.

Fig. 18.—Instrument complete.

We present below cuts of the apparatus of Dr. Allis for the administration of ether. This instrument has been in use in the United States and Europe for the past four years, and may be said to have won a place among the standard instruments.

This and the following cuts are two-thirds the size of the manufactured instrument.

The instrument was first exhibited before the Philadelphia county Medical Society on October 14th, 1874, and described in a paper upon anæsthetics, published in the *Philadelphia Medical Times*, No. 162. It is now made simpler and stronger than the first that were offered to the profession.

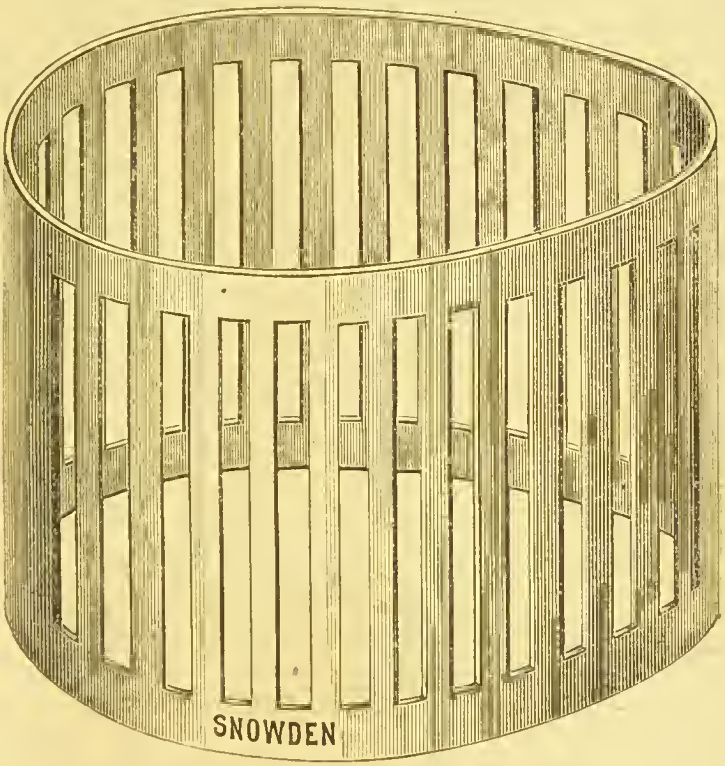


Fig. 19.

Description of the Inhaler.—It consists of a metallic frame sufficiently large to cover the lower part of the face. The bars are nearly a quarter of an inch broad, leaving a quar-

ter of an inch between each and its fellow. The spaces are made by a punch, which removes a section from a solid sheet of metal. It will thus be seen that there can be no danger of the bars giving way, as they would were they soldered upon a band.

In Fig. 20 we reproduce Fig. 19, with a bandage partly laced between the bars. It has been passed from side to

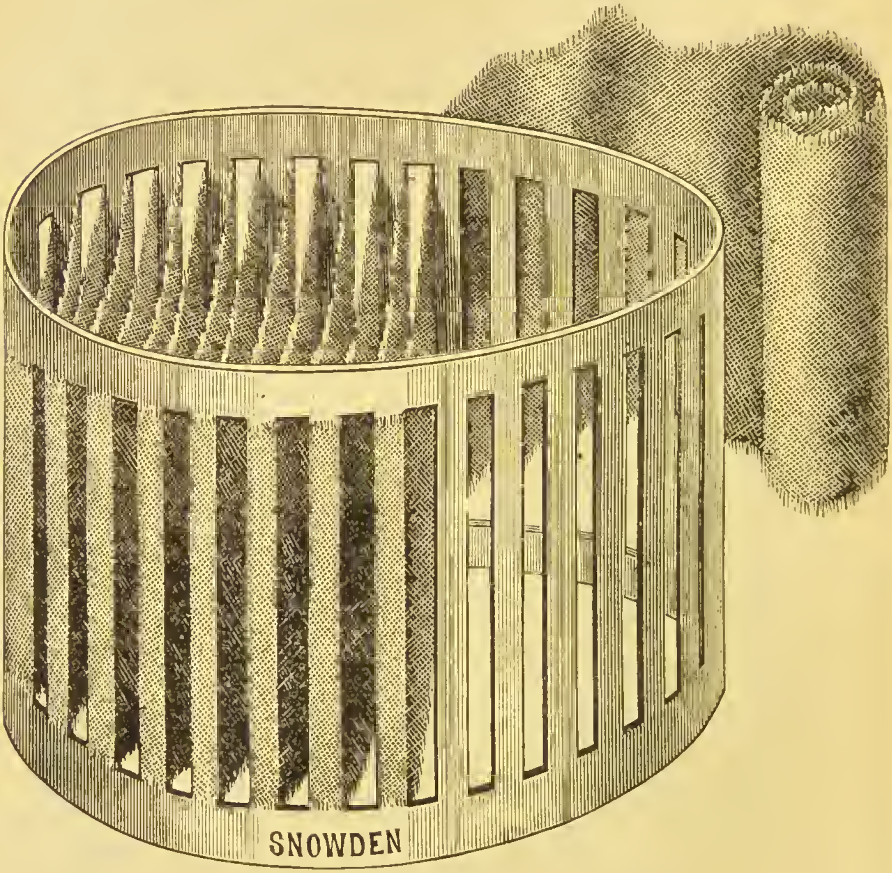


Fig. 20.

side, dividing the instrument into parallel sections. On the right, a part of the bandage may be seen rolled up. When the bandage has been passed between all the bars, and the hood or cover put on (Figs. 18 and 21), one can look through the instrument from end to end, as there is a space

of nearly a quarter of an inch between the several sections of the bandage.

The advantages of this mode of construction are:—

1st. It gives the patient (Fig. 21) the freest access of air. It is a mistake to think that air must be excluded. All that is necessary is that *the air should be saturated with the vapor of ether.*

2d. It affords a series of thin surfaces upon which the ether can be poured, and from which it will almost instantly evaporate. In this respect it differs from the sponge, which retains the ether in a fluid state much longer. Should the bandage become soiled a new one can be inserted in a few minutes.

3d. By leaving the instrument open at the top, the supply can be kept up constantly if desired; and as *ether vapor is heavier* than air, there is no loss by not covering it. *The top should never be covered.*

Mode of using the Inhaler:—

1st. Place a towel beneath the chin of the patient, as experience has taught that a towel should always be within reach in administering anæsthetics.

2d. Place the instrument over the face, covering the nose and chin, and let the patient breathe through it before any ether is applied. This will convince him that he is not to be deprived of air.

3d. Begin with, literally, a few drops of ether; this will not irritate the larynx. Add, in a few seconds, a few drops more, and as soon as the patient is tolerant of the vapor, increase it gradually to its fullest effect.*

4th. When the patient is fully influenced it is well to add a few drops at short intervals, and thus keep up a gradual anæsthetic effect.

The advantages of the Inhaler:—

1st. It presents a large surface for the liberation of ether

NOTE.—A draw slip is furnished with each instrument,—the suggestion of Dr. W. W. Keen, Surgeon to St. Mary's Hospital. This prevents the bandage from being soiled, and can itself be changed in a few seconds.

* When the effect of the anæsthetic is apparent, a single layer of a coarse towel may be laid over the nose and mouth, and the instrument replaced. This is a wise precaution against vomiting or spitting.

vapor. The partitions are made of thin bandage, and the air coming to both sides of each layer, sets the ether vapor free more rapidly than is possible in the use of a towel or sponge.

2d. It is open at the top, and ether can be added constantly if desired, and in small quantities, without removing from the face. The sponge and towel both require removal, and the ether is usually poured on them in quantities.

3d. The ether vapor falls by its weight, as it is heavier than the air; and as the instrument fits the face the patient gets the full advantage of it.

4th. It does not cover the patient's eyes, does not terrify him, and he often passes under its influence without a struggle.

Fig. 21.

5th. By its proper use the laryngeal irritation may be wholly avoided, the anæsthetic effect as easily gained as is possible with the use of ether, a great economy of ether and great comfort to the patient.

Dr. G. H. Coburn, late resident physician of Howard Hos-

pital, carefully recorded all the cases, at my request, occurring during the years 1875-6, in which this form of Allis' inhaler was employed in the various surgical operations performed in the institution. It was found by him that the shortest time required to produce complete anæsthesia in a young female patient was three minutes, and the amount of ether employed was only one fluid ounce. The longest period required in an adult female was seven minutes, and the amount of ether used two ounces and a half. The doctor did not notice in any of the cases but slight redness of the eyes. In a few instances there was a hysterical tendency among the females. If solid food had been taken, vomiting would follow, but after liquid or light forms of nourishment, vomiting was very rare, not more than one in fifty cases. In temperate males the time for full anæsthesia was from five and a half to eight minutes. Ether consumed, minimum quantity two ounces, maximum, three ounces.

The objections to this form of apparatus are:—

1st. That the exhaled vapor is not conveyed to the floor, but is diffused in the air, to be breathed by the operator and his assistants. For a single operation, this is not of much importance, but where there are a number of cases the arrangement is not conducive to the comfort of the operator.

2d. The bandage of muslin across the bottom becomes clogged with moisture and saliva, and at times by discharges from the stomach, and cannot be so readily removed.

3d. Owing to the peculiar arrangement of the muslin strips, it is tedious when it is required for a number of patients to remove or replace them.

In a conversation with Dr. Allis, he stated that he considered the chief merit of his instrument was, that it thoroughly and instantaneously liberated the ether, and that while there was not the least impediment to respiration, yet all the air was impregnated with the anæsthetic.

Neither ether nor chloroform can be inhaled in the pure state.

It is always atmospheric air, impregnated with the anæsthetic, that sustains life and produces anæsthesia.

The expression "give him nothing but ether, exclude the air," are only relative terms; they simply mean *saturate the*

air as much as possible with the ether. Permit the patient to have *no fresh air*, but *compel* him to breathe *air charged with ether.*

Now, in Allis' apparatus there is no chance for the ether to remain in its fluid state, but exposed as it is on a thin stratum of muslin it yields its anæsthetic principle promptly.

When he first employed his instrument, bystanders would suggest that it be closed at the top, so as to permit no escape of ether.

This will show that the true laws of ether were overlooked; ether-vapor, while it will diffuse itself throughout an entire room, is of greater specific gravity than atmospheric air and tends to the floor.

To close this apparatus at the top, would necessitate ingress of air at the part surrounding the mouth, for air *must* be admitted.

If it be excluded at the bottom and left open at the top, the advantage of having a constant supply of ether dropping upon the folds is very great.

Some suggested that the frozen moist vapor that is seen at the top of the instrument indicates a waste of ether, but the small quantity used and the rapidity with which anæsthesia can be effected, are complete refutations of this.

The untidiness can be entirely avoided with a little care.

The late Dr. Morgan, of Dublin, has comparatively tested the cone and sponge with the inhaler, and finds that the time is not only much longer in the first form of apparatus, but the effects also far less satisfactory both as to the temporary and after condition of the patient.

Mr. Morgan, Surgical Registrar at St. George's Hospital, London, has suggested a modification of the felt cone ordinarily in use in this and other hospitals in England.

"The instrument consists of a cone of felt, in the apex of which a piece of sponge is fixed, on which the ether is poured. This is fitted into a case of metal surrounded by an outer one of similar shape, but sufficiently large to leave a space between them through which the expired air can freely circulate before it escapes. There are two valves, acting in opposite directions; one admitting the air, which passes through the sponge moistened with ether; the other, through which it escapes into the chamber between the two

metal cones. The close application of the instrument to the face is secured by means of the India-rubber cushion, which is filled with air by the tap, so that all the air inspired must pass through the valve. The warmth produced by the air which circulates between the two cones prevents the ether on the sponge from freezing, and the vapor which escapes is carried off by a tube to any distance which may be desired. The quantity of ether required in this apparatus is much smaller than in the ordinary cone; and the advantage it thus possesses, as well as the safety and freedom from ether-vapor obtained by the administrator, render it superior to other similar apparatus. Several American surgeons, whose knowledge and experience of ether are generally recognized, have expressed considerable approbation of this invention. It is manufactured and sold by Messrs. Blaise & Co., 67 St. James Street."

The following results* were obtained by the use of Morgan's inhaler:—

REPORT OF EXPERIMENTS WITH ETHER IN TWENTY-SIX CASES.†

Shortest time taken to place a patient under the anæsthetic influence,	3 min.	30	seconds.
Longest time,	24 "	0	"
Average time,	8 "	10	"
Average time under influence,	19 "	6	"
Smallest quantity of ether used in one case,	2 ounces	4	drachms.
Largest,	9 "		
Average,	5 "	1	"

Vomiting occurred in eleven cases during or after the administration of the drug. Excitement occurred in seven cases to a marked degree during or after administration of the drug. (Does our experimenter mean resistance as excitement, or, if in a female, as hysterical excitement?) The anæsthetic was invariably given on an empty stomach. The ether was given by Morgan's inhaler. Ether was analyzed and found to be perfectly pure, s. g. 720.2 at 64° F.

* Those who have used both the English and American ethers state that the former gives less favorable results than our washed ether, æther fortior, U. S. P.

† By Surgeon-Major Porter, Assistant Professor of Military Surgery. London: 1875.

ETHER INHALER OF DR. RICHARDSON.

In 1873 Dr. B. Willis Richardson,* of Dublin, designed and employed a simple form of ether inhaler for use in hospital practice. The ether box, of metal, has a capacity of three ounces, with an oval air-opening half an inch long, and about an eighth of an inch from its upper margin. By rotating the lid, which has a similar shaped opening in its side, the admission of air can be easily regulated. At the beginning of the inhalation, the inner opening may be fully exposed and gradually covered. The ether box communicates with the face piece by means of a tube an inch in length and one inch and a half in diameter, the ether-box opening of the tube being two-thirds closed by a fixed diaphragm. This prevents the fluid ether from passing into the tube when the patient is in the horizontal position. The face-piece opening of the tube has a diameter of one inch. The tube itself, in order to increase the evaporating surface, should be nearly filled with soft cotton candlewick, having, when in use, one end submerged in the fluid ether. The inhaler may be made of silvered copper or of block tin, but the margin of face-piece should be formed of flexible metal and covered with morocco leather.

"This inhaler the inventor states to be simple in form and moderate in price, and designed as a substitute for the towel and sponge, in the use of which there is much waste of ether, a matter in hospital economy that may be of some importance."

Dr. Richardson has employed and prefers anhydrous sulphuric ether, because it was found to produce the most rapid anæsthesia.

DR. ANGROVE'S HANDY ETHER INHALER.†

This gentleman states that in England there is a great want felt just at present for an effective, handy and cheap inhaler. He has endeavored to supply this want. His inhaler "consists of a cylinder, on which fits, by a bayonet

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* Description and illustration of an ether inhaler, etc. By B. W. Richardson, F.R.C.S.I. John Falconer, Dublin, 1873.

† The description of a handy ether inhaler. By W. T. Angrove, House Surgeon to the Yarmouth Hospital. "London Lancet," March, 1877, p. 123.

joint, a cap, around the rim of which are attached several stout wires. The top of the cap is perforated with holes, and through the middle is inserted a long metal tube reaching nearly to the bottom of the cylinder. One end of an air-tight silk reservoir is fastened to the cap, and the other to the flexible tube, which is also attached to the mouth-piece. The flexible tube runs through the reservoir, and is directly connected with the metal tube. The inside of the cylinder is lined with felt, and a couple of turns of the same material are wound round the wires, thus presenting three surfaces for the evaporation of the ether. Having filled the reservoir with air, an ounce of ether is poured into the cylinder through the nozzle; this diffuses itself all over the felt. The mouth-piece is then applied to a patient; he is told to 'draw in his breath;' the vapor he inspires comes from the reservoir, passes through the holes in the cap, over the evaporating surfaces of felt, and up through the whole length of tube; he expires the same vapor which passes back to the reservoir, and becomes re-charged with ether during the next inspiration. The inventor further states he has completely anæsthetized several individual patients in a little over one minute, one in forty seconds. An ounce of ether is sufficient to keep a patient about ten minutes."

The cylinder is five inches high and three in diameter. The reservoir holds about a pint and a half. The length of the tube can be made according to taste. To show that they are still at sea in England in regard to ether inhalers, I will conclude this part of my subject by giving a description of one of the latest invented, from the *British Medical Journal.*

THE PORTABLE REGULATING ETHER INHALER OF J. T. CLOVER, F. R. C. S.

"In the *British Medical Journal* of July 15th, 1876, I described an apparatus for giving laughing gas and ether separately or combined. Experience in more than three thousand cases in which I have used it convinces me that the administration of ether may be made far less unpleasant to the patient, and equally effective and safe, by first giving enough gas to render the patient unconscious of its taste.

"The arrangement of the apparatus enables one to cause

the patient to breathe directly into and out of a bag, or partly or entirely through a vessel containing liquid ether. Even without gas, it is very efficient, inasmuch as it gives the power of varying and of sustaining the strength of the vapor. I have used it a great many times without gas, and find it as safe as any other way of giving ether, whilst the risk of coughing and sickness is much lessened.

"The plan of excluding fresh air until insensibility has been induced, and admitting it very sparingly afterwards, has now been extensively tried in various ways, and, so far as I know, it is practically free from the danger of causing serious obstruction to the pulmonary circulation and over-distention of the right cavities of the heart. Of course, air cannot be indefinitely excluded, but the pulse and respiration give timely notice when air is required. A single artificial respiration of fresh air in these cases affords more relief than several such respirations when the apnœa has resulted from an overdose of ether or chloroform. The reason for this is, that in the former case the symptoms depend chiefly on the want of oxygen, and in the latter upon the presence of a substance which has not only entered the blood, but has penetrated the tissues of the body. If the apparatus be overheated, or if the ether be turned on too quickly, the ordinary coughing and struggling would, of course, be produced. The apparatus, however, requires a little more attention to temperature and other details, and is rather too complicated for general use. I have made several attempts to avoid the necessity of warming it. This can be effected by having the ether vessel surrounded by a larger quantity of water at the ordinary temperature, but then the size and weight of the inhaler becomes objectionable. Better success attended modifications of the instrument having the ether vessel placed close against the face-piece, so as to receive more warmth from the patient's breath and from the hand of the administrator.

"I am greatly indebted to Messrs. Mayer and Meltzer for their patience and ingenuity in carrying out my ideas, and my present object is to call attention to a portable regulating inhaler made by them. Its advantages are these: 1. It has no valves; 2. It supplies the vapor so gradually that patients breathe quietly; 3. It produces sleep in two minutes;

4. It does not require fresh ether during the continuance of an operation; 5. The recovery from a short operation is more speedy than with most other inhalers; 6. It does not need to be warmed before it is used; 7. No sponge or felt is required; 8. Ether left in the inhaler can be saved for another time.

"The face-piece is edged with an air-cushion. The ether vessel and water chamber rotate upon the mouth of the face-piece. When the instrument is first applied, the stopper should be towards the patients forehead, and now he breathes in and out of the bag directly. As the ether vessel is turned round, the air is obliged to enter the ether chamber and pass through it before it reaches the bag; and when the vessel is turned half round, so that the stopper is opposite the patient's chin, all the air going in and out of the bag must pass through the ether vessel. Two ounces of ether (specific gravity 735) are enough for a long operation. Usually an ounce and a half is the proper charge. The opening for supplying the ether is arranged to prevent an excessive quantity being supplied, but to guard against the possibility of a few drops escaping through the inner openings, there are two recesses made to catch them, and prevent the liquid ether from reaching the patient's lips.

"The ether vessel is spherical in shape, and one half is surrounded by a closed water compartment to prevent the ether from becoming too cold. The bag need not be much distended when in use, and can be kept on one side so as not to obstruct the light in operations on the eye. The instrument is intended for giving ether without gas, but by connecting the bag with a supply of nitrous oxide, it forms a tolerably efficient substitute for the gas and ether inhaler above mentioned."

CHLOROFORM INHALERS.

A simple form of inhaler for the administration of chloroform, devised by Dr. Allis, of this city.* See Fig. 22.

"It consists merely of two tin cones soldered apex to apex, with a tube projecting from the upper or receiving cone into the lower. Around the base of the larger cone a piece

* Philadelphia Medical Times, No. 162.

of linen is tied. When the instrument is to be used, a towel is properly folded and pinned around the larger cone, presenting, when complete, a cone of sufficient size to cover neatly the mouth and nose.

"This cannot be called an inhaler with any more propriety than can a towel or a napkin; but while it resembles the latter in principle, it has in practice very many and important advantages.

Fig. 22.

"1. The chloroform falls through the tube upon a single layer of linen to both sides of which the air has ready access, and is accordingly instantly evaporated.

"2. Every drop is conveyed to the patient.

"3. A few drops at a time are all that are ever required, and all the patient can breathe with comfort.

"4. The dropping may be more or less constant, as the instrument need not be removed from the face, and by means of a 'dropper' (see Fig. 21), the operator can gauge the amount to the necessities of the case.

"5. The anæsthetic influence is gained gradually, imperceptibly and rapidly, and with a minimum amount of chloroform. I seldom use more than a drachm and a half in adults.

"6. As only a few drops need be added at a time, the danger must be far less than when an indefinite quantity is poured on from a bottle at once.

"7. There is no exclusion of the air, but the air that is breathed is impregnated with a fresh supply of chloroform.

"8. The time consumed is usually from three to ten minutes.

"9. The influence once obtained may be easily maintained.

"We have used this repeatedly for nearly four years, and have found it all that we could desire.

"It is exceedingly convenient as a frame work about which to pin the towel, and as a receiver of the chloroform, and so simple in construction that any tinsmith could make or repair it should it be broken."

SKINNER'S CHLOROFORM INHALING APPARATUS.

This consists of a wire frame (like those employed in Germany); it is in the form of a scoop net, which, when in use, is covered with a thin flannel or domette drawn tight. There is an accompanying green glass bottle for the chloroform, with a stopper and cap, and on removal of which a tubular stopper is fitted so as to use it for a dropper.

Directions for adjusting.—Adjust the domette cover by passing the handle of the inhaler through the slit up to the hinge; then draw the India-rubber opening over the wire frame, keeping the side on which the facial or horizontal wire is, looking upwards.

Adjust the horizontal or facial wire (under the domette), and keep it in position until you have unfolded the handle. See that the small notch in the hinge extremity of the handle receives the facial wire and fixes it; then turn the instrument over, and fix the nut or bolt beneath the handle.

There are two domette covers with each instrument. When soiled, or, indeed, after administering chloroform to any patient, a fresh cover should always be put on.

Directions for using.—Never charge the bottle with over three fluid ounces of chloroform, namely, to the top of the tell-tale or slit in the leather cover, otherwise the contents will not flow freely enough when wanted.

In adjusting the tubular stopper see that it is firmly "sent home" with a turn, so that there will be no likelihood of its falling out during use—an accident which hitherto has not happened.

The inhaler or mask is to be held with the left hand, close to or more or less distant from the nose and mouth of the patient, whilst the chloroform bottle, with the small glass cap removed, is to be held in the right hand, and its contents are to be *poured in a stream* over the surface of the domette (while *in situ* over the face of the patient) in such quantities as the administrator may think advisable—in fact, the bottle is to be used the same as a watering-pot for flowers. But it is necessary to bear in mind that, in consequence of the peculiar construction of the stopper, only from

fifteen to thirty minims can flow at one inversion of the bottle; air must be re-admitted, either by a fresh inversion, or by shaking the bottle while in the inverted position, in order to re-establish and keep up the flow when necessary.

The instrument in its present form has been used most extensively to induce the deepest anæsthesia in capital operations. In the more violent forms of mania, epilepsy, and delirium tremens, it has also been extensively used. It has been used in dentistry, in general surgery, and in midwifery, in all conceivable positions of the body; but the back and sides are the positions most to be preferred, as regards rapidity of effect, economy of the anæsthetic, and the safety of the patient. In point of economy alone, this apparatus saves at least sixty per cent. of chloroform more than any other practical method of successful administration.

THOMAS' NITROUS OXIDE INHALER.

The Thomas inhaler, Fig. 23, is turned from a piece of vulcanized rubber, eight inches long by three inches square, leaving the mouth-piece one inch and a half across. The diameter of the opening is a little more than one-half an inch, with stopcock in the centre, in which is the inhaling

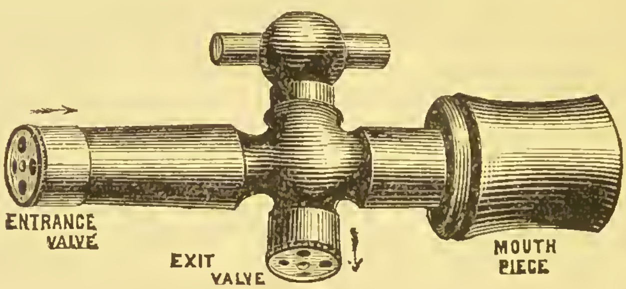

Fig. 23.

valve, which is constructed of a simple piece of rubber dam secured by a pin to a stoppel, in which are three oblong apertures, as is the inhaling valve at the extremity of the inhaler. The aperture being of sufficient size, is made not to obstruct the free passage of the nitrous oxide gas, the valves are three-quarters of an inch in diameter, and the stopple is of vulcanized rubber. His method of using it is described under nitrous oxide, page 164.

CLOVER'S INHALER FOR NITROUS OXIDE GAS AND ETHER.

The following is a description of the apparatus of Dr. Clover:—

"The apparatus consists of a thin bag, oval in shape, and fifteen inches long; at one end connected with the ether vessel, at the other with the face-piece. Inside the bag there is a flexible tube also connected with the face-piece and ether vessel.

"By turning the regulator (Re) the patient is made to breathe either directly into the bag, or indirectly through the tube or ether vessel.

"When the letter G is visible, the way to the gas bag is open; when the letter E is visible, the only way to the bag is through the tube and ether vessel; so that the more the regulator is turned toward E, the more ether is given, and *vice versa.*

"The other vessel contains a reservoir of water to prevent the temperature of the ether becoming too low; this is to be kept full.

"The ether vessel is to be rather more than half filled, the precise point being marked against the glass gauge. A thermometer inside this gauge tells the temperature of the ether. Before using it, the vessel should be dipped into a basin of warm water, and rotated until the thermometer stands at about 68°.

"If the room be cold, and if the patient have thin cheeks and large whiskers, the temperature may be 73°.

"It is important that the face-piece should fit closely against the face. Those made by Mayer, of solid leather framework supporting a collar of inflated india-rubber, are the best, but sometimes they require to be warmed before using. For giving nitrous oxide only the regulator is turned to G. The stopcock of the ether vessel is closed.

"This vessel is hooked upon the strap round the neck. The strap is adjusted so that the ether vessel stands at a higher level than the face-piece.

"The gas being turned on by rotating the foot key with the foot, the gas bag is kept filled as fast as it is emptied by the patient. When the latter breathes out, the supply of

the gas is stopped, and after the bag is fully distended, the escape-valve opens, and allows the expired gas to escape.

"If the shape of the patient's face prevent the face-piece from fitting closely, the escape-valve should be closed by pressing it with the finger. Enough gas will escape beneath the face-piece during the expiration. But the bag, being slightly distended, will yield the gas so abundantly, that no air will be drawn in at the same place during the inspiration.

"If ether is to be used without gas, the gas-tube should be taken off the ether vessel, the regulator should be turned to G, and the face-piece should be first applied to the face during an expiration, and be held rather closer during expiration than during inspiration.

"It is important not to oblige the patient to inhale after the bag is empty, because the barometric pressure of air on the ether being diminished, the vapor would increase in strength, and make the patient cough or perhaps vomit.

"The regulator is gradually turned towards E, and thus the way is opened to the inner tube. The air breathed through it carries vapor from the vessel into the distal end of the bag.

"As soon as one-half of the air passes through the ether vessel, the vapor becomes strong enough to cause insensibility in about two minutes, usually without any coughing. As the movement of swallowing is excited by a too strong, although less pungent, atmosphere than is generally needed to excite coughing, it should be watched for, and the regulator slightly turned back if it occur.

"By far the easiest and least unpleasant way of getting a patient ready for a surgical operation is to use gas and ether combined, the gas being given pure during four or five respirations, and the ether gradually added as above described.

"The supply of gas should cease when the ether is turned on; but if during the operation we have admitted so much fresh air that the patient seems conscious of the taste of ether, we may, instead of increasing the ether, give a liberal supply of gas until the patient is tranquil.

"I find less sickness and less complaint of the taste of ether afterwards than when ether is used alone.

"In operations on the eye, the muscular twitching and panting character of the breathing during the first few minutes of insensibility are objectionable; but if the operation be not commenced for five minutes, and the ether given as strong as it can be taken without exciting a cough, the patient begins to breathe stertorously, and now the face-piece may be removed every third or fourth inspiration, and as the stertor goes off, the eye will become quite steady.

"I am, however, so well satisfied with a modification of my chloroform apparatus, by which I can give as much of ether or chloroform as I like, that when I have a choice, I prefer using these for cataract operations, and for the ligature of deep-seated arteries, etc.

"With respect to vomiting, I think it most important that the patient should have an empty stomach, and prefer that neither food nor drink of any kind should be taken for from four to six hours beforehand.

"There is less sickness after operations if done before breakfast.

"In using this apparatus, as in using others, the breathing and the pulse should be kept under observation.

"Whenever we see a patient swallow, it is probable he is taking the vapor stronger than is necessary, and the regulator should be turned back slightly.

"If the patient cough violently, remove the face-piece, and be sure that the apparatus has not been overheated or filled with ether above the proper level.

"As soon as any muscular twitchings, like those of paralysis agitans, are seen, give about a fourth of an inspiration of fresh air, and do not keep the face-piece quite close to the face till the twitchings have nearly ceased.

"I have never seen any harm result from the condition which causes these movements. If air were not given, they would increase, and then stop; the respiration would become intermittent, and some time after this the heart would cease to beat.

"The fact that death may be produced if signs of danger are disregarded applies to all anæsthetics.

"Whenever the breathing becomes jerking, sobbing, or intermittent, the face-piece should be removed, but applied

directly the breathing loses that character, unless the pulse is much depressed.

"It is much less important to watch the pulse whilst giving gas and ether than in giving chloroform; but it is desirable, for when it decidedly loses power, we may safely admit a little fresh air, and thus anticipate the need of removing the face-piece to a greater extent on account of muscular twitching or stertor.

"If the finger be taken from the pulse to do something else, I would give a little air, unless the patient had only just begun to inhale, or was evidently but slightly under the anæsthetic.

"Practical suggestions:—

"As the apparatus would be injured by an excited patient taking hold of it, it is as well to have an assistant near in case of need.

"It is a good plan to replace a handkerchief over a patient's eyes, and keep it there until he is asleep, and apply it again when he is about to awake.

"In operations on the rectum, it is desirable that the bandage required for keeping him on his side should be applied before giving the gas.

"Sudden distension and bursting of the gas-bag or gas-tube can scarcely happen when the gas rarefier is used; but if this be not used, or if the gas-bottle have become frozen, it is desirable to warm the bottle, and in doing so, the top end should be more warmed than the other.

"Whenever there is much difficulty in getting the face-piece adjusted, it may be necessary to arrange a handkerchief or towel so that the air drawn in under the face-piece may be nearly the same as that which was breathed out.

"In conclusion, the advantages of the apparatus are these:—

"1. It lessens the waste of ether, and consequently the odor of ether about the house.

"2. The patient usually goes to sleep without any struggling, and is ready to be operated on in from one to two minutes.

"3. The percentage of ether need not be so high as to produce coughing or swallowing, and it can be made stronger or weaker, as we wish, by merely turning a regulator.

"Lastly, patients recover rapidly, with less delirious excitement and less sickness, than if ether be given in the usual way."

In April, 1877, Dr. F. N. Otis, of New York, exhibited Clover's apparatus for administering ether and nitrous oxide, and remarked that it had given him the best satisfaction of any apparatus he had ever employed, for anæsthesia was readily produced without a struggle upon the part of the patient. It could be used for the administration of laughing-gas without producing any of that dreadfully suffocative appearance so commonly attending its use by the methods usually employed. He thought well of prefacing the ether by the use of a moderate amount of nitrous oxide.

Death under the administration of nitrous oxide and ether.—"A death has recently taken place in London, at University College Hospital, during anæsthesia from nitrous oxide gas and ether, being, we believe, the first fatal case which has occurred in this country that can be attributed to this combination of anæsthetics. The patient was a woman fifty-five years of age, who was admitted to the hospital in consequence of strangulated femoral hernia. When admitted she was in a very weak and exhausted condition from constant vomiting, the hernia having been strangulated for over forty-eight hours. She was taken into the operating-theatre, and gas and ether administered by means of Clover's apparatus. In about four minutes she was well under the influence of the anæsthetic, without having exhibited any previous excitement. Taxis was then applied, when almost immediately the patient became pale and recommenced vomiting stercoraceous matter. At the same time the respiration became weak, and the pulse at the wrist imperceptible. The doors and windows of the theatre were at once thrown open, and artificial respiration was carried on for a few minutes. As no obvious benefit resulted, an enema, containing three ounces of brandy, was administered. Fumes of strong ammonia were applied to the nostrils, and ammonia injected into the right median basilic vein, but all without any good result, and the patient died within about ten minutes from the onset of the alarming symptoms. At

the autopsy, stercoraceous matter was found in the trachea and right bronchus. The right side of the heart and the large veins were full of dark fluid blood. The ventricular walls were thin and flabby, and the cavities slightly dilated. The left ventricle was empty. The arch of the aorta presented numerous patches of atheroma."*

Sir Henry Thompson recommends Mr. Clover's plan of administering nitrous oxide gas for thirty seconds and then ether.†

INHALER FOR NITROUS OXIDE GAS OR ETHER OF CODMAN AND SHURTLEFF, OF BOSTON.

I have received a beautiful inhaler from the above firm, through the politeness of S. S. White & Co., of Philadelphia.

The points for which they claim superiority are:—

"1st. Durability; being made of metal, they are not liable to be easily broken, as so frequently happens to the hard-rubber inhalers, and as they are nickel-plated they retain their brilliant polish without change.

"2d. For convenience both to the patient and operator. With one hand the latter can apply the inhaler, and open or close the two-way stopcock, leaving the other hand at liberty to control the patient, or for such exigencies as may occur. As the elastic hood covers both nose and mouth, the patient is saved the necessity of having the nostrils closed either by clamps or the fingers—a part of the operation always very disagreeable, and to very sensitive patients positively frightful, as it produces a feeling of suffocation.

"Cleanliness. The rubber hood, which alone comes in contact with the face, is easily removed and replaced, and as all the other parts are either metal or hard rubber the whole instrument can be kept perfectly pure by washing, which is a point of great importance to the comfort of the patient.

"4th. Durability and accurate working of the valves."

Upon this, perhaps, more than anything else, depends the successful administration of anæsthetics. If the ex-

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* Medical Times and Gazette, March 17th, 1877.

† London Lancet, January 8th, 1876.

haling valve does not quickly and perfectly close while the gas is being inhaled, air is taken with it, and the gas is so much diluted that it very much delays or wholly prevents the desired effect.

If, on the other hand, the inhaling valve does not work properly, the patient breathes back into the reservoir a mixture of nitrous oxide and air.

Fig. 24 is the inhaler with a hard rubber mouth-piece, A. The metal hood, B, is used for nitrous oxide gas.

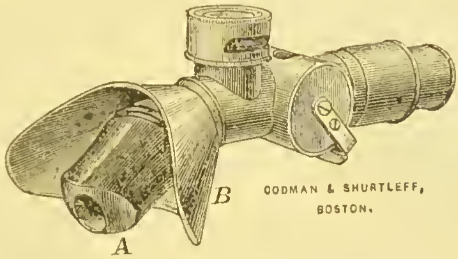

Fig. 24.

Fig. 25 is the inhaler for nitrous oxide gas. A, metallic hood, containing, B, flexible rubber hood, covering both

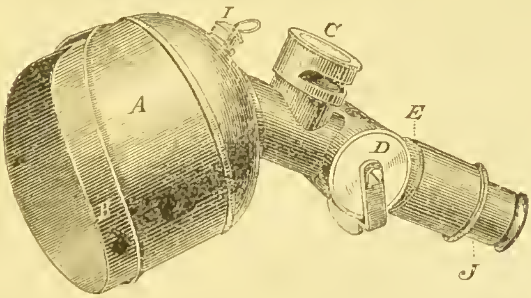

Fig. 25.

nose and mouth; C, exhaling valve; D, two-way stopcock; I, packing, through which a silk cord passes; E, sliding-joint, where J is detached to connect the ether reservoir; J contains the inhaling valve.

Fig. 26, the inhaler arranged for using ether. This differs from Fig. 25 only in the addition of the hollow sphere, F, which contains a course sponge, on which the ether is poured through the opening, G; H, cover closing the reservoir when not in use. This part is attached at the sliding-

joint, E, and will fit most inhalers made by Codman & Shurtleff during the last three years. By this arrangement waste of ether by evaporating is prevented, and it is stated that less than half the quantity is required to produce or keep up anæsthesia.

The operator also escapes breathing so much of the ether as he is compelled to do when using it from a sponge or napkin.

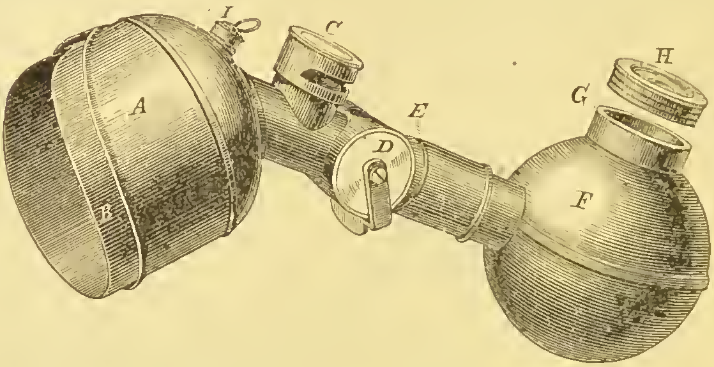

Fig. 26.

EXPERIMENTS MADE WITH THE INHALER OF CODMAN & SHURTLEFF, BOSTON.

First experiment with new inhaler, November 1st, 1876, with three patients, two males and one female.

In each was tested the ether attachment: two were unable to make the valve act quickly; in the third the operation of inhalation was a success, the exhaling valve acting with each respiration by a click.

Nov. 2d. Second experiment, two females and one male. With the females the soft rubber covering for the mouth, nose, and face fitted admirably. With the male the rubber cover could not be made to fit air-tight, owing to his having a beard, but it worked more satisfactorily. If the distance from the ether supply and the mouth-piece is shortened, the ether passes much more rapidly in the case of a patient who is feeble.

The exhaling valve should be screwed tightly, else it is apt in handling to become loose and will drop out.

Third experiment. Dr. Thomas has demonstrated that the gag was not suitable, for it should not project out of the

mouth to prevent its perfect closure. Second, it did not fit into the teeth.

I have received the following reply, from the makers, to a report of my experiments:—

"SIR: We have received yours of the 3d. In regard to the fit of the rubber to the patient's face, we have had no complaints, except where the beard in male persons has prevented close contact, and in cases of children where the face is too small to fit the rubber. In the former class of cases the beard may be wet with water, or that failing, the mouth-piece used instead of the flexible face-hood, which is the plan to be pursued with children.

"We have adopted this style of face-hood in preference to the English pattern, that having an air tube attached to the metal hood, as being as well or better adapted to a great number of faces and not liable to get out of order, as that is almost sure to do after a few months' use, and as being removable for cleansing or removal without any expense or delay.

"The Centennial Judges, who took ample opportunity to examine this inhaler, refer to it in the report accompanying the award to us of the highest prize, in the following terms, viz.: 'The novelty of design of the inhaler, perfection of its execution, and general suitability to the rapid and safe administration of anæsthetics.'"

MORGAN'S INHALER FOR BICHLORIDE OF METHYLINE.

Mr. T. C. Morgan employs "a perforated cardboard frame covered with flannel and fitted with lappets, to lie over the face so as to completely exclude air. Two drachms of the bichloride of methyline are put into the inhaler, and it is so closely held before the face as to allow no air to be breathed except what passes through the flannel. In less than two minutes the patient is usually completely insensible. Another drachm is then put into the inhaler and given as required." He does not care to watch the pulse, though this is sometimes much retarded. He watches the lips and breathing. When the lips become white and bloodless, he stops the administration, fearing pallor, not lividity, for patients die from syncope, not coma.

CHAPTER IX.

Bonwill's method of anæsthesia. Analgesic effects of rapid breathing. Carbonic oxide gas. Carbonic acid gas. Carbolic acid. Tetrachloride of carbon. Anæsthesia of the larynx. Local anæsthesia in odontalgia. Faradic anæsthesia. Bromoform. Local anæsthetics. Richardson's freezing mixture. Extract eucalyptus, morphia, etc.

BONWILL'S METHOD OF ANÆSTHESIA.

The method of diminishing sensibility by rapid respiration proposed by W. G. A. Bonwill, D.D.S., of Philadelphia. It is described by Dr. A. Hewson in the Philadelphia *Medical Times*, March 4th, 1876. .

"You have, all of you, I have no doubt, experienced the effects of rapid and deep respirations, after violent running, or blowing hard to ignite a fire, especially the confusion of sight and bewilderment of mind. These Dr. Bonwill recognized many years ago, associated with numbness of sensient nerves, as dependent on the rapidity of the respirations. Pursuing the subject he has brought it to practical use in his profession—that of dentistry—in which he uses it constantly to diminish the sensitiveness of dentine, and even to produce such insensibility as to allow of the extraction of a molar tooth without pain. Of the latter I have had a demonstration in my own family, which has led me to the study of the subject myself, and with the most gratifying results. I have used it in stitching wounds, in handling over-sensitive parts, and in probings and the like." He then relates the case of a medical gentleman who tried the experiment with success who had no recollection afterwards of a "pin sticking him, much less of its having been firmly imbedded in his flesh, as he found it when he had ceased the rapid respirations, and the anæsthetic effect had passed off."

His second trial was upon a boy in the receiving ward of the Pennsylvania Hospital. The boy had fallen upon the ice an hour previously, and had sustained a severe injury of his left wrist. The doctor directed him at once to try the

rapid respirations. This, in two minutes and a half by the watch, caused some dizziness in the boy's head, when the doctor picked up the limb and moved it about with the utmost freedom, diagnosing a bad sprain of the wrist, and the absence of fracture. When the boy was recovering he took to crying, on account, he said, of the dizziness and confusion he had experienced. Nothing, remarked the doctor, could have been more satisfactory than this case in its results. Dr. Bonwill claims that a much smaller quantity of ether, chloroform or nitrous oxide is required to produce complete anæsthesia, if rapid respiration is employed for one or two minutes prior to the use of these agents; this he states is corroborated by experiments of Professor Garretson, of this city.

ANALGESIC EFFECTS OF RAPID BREATHING.

Dr. Addinell Hewson, of this city, communicates an interesting paper on the history of nitrous oxide gas as an anæsthetic, and on the analgesic effects of rapid breathing (Transactions of International Medical Congress, 1876).

CARBONIC OXIDE GAS.

When carbon in the form of charcoal is burned with an insufficient supply of oxygen or atmospheric air, it is converted into carbonic oxide, CO; if there is a full supply of air, it yields carbonic acid.

As I have before stated, carbonic oxide has been employed as a local anæsthetic to cancerous or ulcerated surfaces, but when inhaled, as it often is in mines and by accident, and sometimes by design for suicidal purposes in confined apartments in which charcoal is burned, it is a powerful narcotic poison. Owing to its superior affinity, it displaces the oxygen in the blood corpuscles, and unfits them for the functions of respiration. Carbonic oxide, which gives the blood a light red color, produces a spectrum with two absorption-bands similar to those of normal blood. The red and violet rays are more completely absorbed than in the spectra of normal blood, but with a strong solution of the red coloring matter the results are similar.—(*Preyer.*)

This gas is interesting to physicians as being one of the most successful agents employed to destroy animal life, and

is employed by the "Society for the Prevention of Cruelty to Animals," of our city, to get rid of the superabundant dogs which infest a large city during the summer months.

*Illustration of the mode of killing dogs by the carbonic oxide gas.**—The place in which the act is accomplished is a small brick building twelve feet six inches long, eleven feet wide, and twelve feet high, containing two rooms, one on the ground floor, and one above it. The lower rooms run along the whole width of the building, eleven feet, and is fourteen feet five inches broad, a partition of brick separating it from the rest of the space beneath. At the east end it is two feet eight and one-quarter inches high, its roof or top being a little higher than the floor of the room above; the incline of the roof upwards to the window makes that end of the room four feet four and one-half inches high; the incline was made to allow more light and an examination of the process of killing. One window is four feet three and one-half inches long, and one foot five and one-quarter inches wide. The two others are three feet five and one-half inches long, and two feet six inches wide; each of these windows has a sash of glass and one of wire; the sashes lift in and out. The window on the top is one foot four inches square. The floor is of brick, and the floor, ends and sides, are covered with cement to make the room air-tight.

In the two stoves in the room above the gas is generated; they are known as the Rosebud pattern, No. 13, holding about one-half a bushel of charcoal each; each has a pipe twenty-two feet six inches in length, with a cross pipe running into the chimney. This length of pipe is necessary that the gas may be cooled before reaching the animals. There are four valves or dampers in the pipes—two in the cross pipes, and two just above them in the main pipes. There are also valves at the end of each pipe where it enters the lower room; these valves are opened and shut by the pulleys (which are not connected with anything else); they are "ground seat valves," six inches outside diameter, or in other words, to fit a six inch pipe; they are made of copper.

Mode of killing.—The fire is started, having the dampers

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* This mode was adopted by the Society in 1874, on the recommendation of Mr. Coleman Sellers.

turned so as to send all the smoke and heat up the chimney. When the fires are well ignited, the dogs are taken into the lower room by the window, and the wire sashes are put on. As soon as the blue blaze of the carbonic oxide gas is seen in the fires, the windows of the lower room are shut, the dampers are reversed, so as to send the gas into the lower room, and the valves are opened at the end of the pipes, so as to draw the gas more rapidly down, making a draft by opening one inch or two of the window at one end. In the course of from one to three minutes, the dogs fall insensible with a peculiar cry, and very soon cease to breathe; they are allowed to remain from eight to ten minutes, to be sure that life is entirely extinct.

CARBONIC ACID GAS.

Carbonic acid gas has been used in a few instances as a local anæsthetic, but it requires great care not to allow the patient to inhale it except very much diluted with air. It is made by the action of dilute sulphuric or hydrochloric acid on marble dust or carbonate of lime; also by the action of equal parts of bicarbonate of sodium and tartaric acid in water. In order to facilitate its local application a special apparatus is required, such as a siphon bottle armed with an elastic tube, through which the gas is allowed to pass to the parts to which it is applied. A strongly charged bottle of carbonic acid water will answer the same purpose. The late Professor Dewees, of Philadelphia, recommended it in carcinoma uteri; it is as useful in cancer of the rectum and other parts.

Physiological action.—Dogs can breathe a mixture of one part of carbonic acid to nine of atmospheric air with safety, producing an anæsthetic sleep, and it can even be increased to one third; but when the gases are used in equal proportions, and kept up for some time, death ensues, preceded by labored respiration, complete muscular relaxation, and slight spasms. According to M. Demarquay* when the proportion of carbonic acid to oxygen is as three to one, the first effect is convulsions, followed by complete anæsthesia, even of exposed nervous trunks, followed by death, if kept up.

* American Journal Medical Science, Oct., 1865, p. 497.

THE ACTION OF CARBONIC ACID ON MAN.

If this gas is well diluted with air, or in water, cider or wine, its gas is not only respirable but agreeable, and will often relieve sickness of the stomach. When inhaled it produces an anæsthetic effect. In a young man who died in the Grotto of Pyrmont, there was no congestion of the face, the pupil was dilated, and the cornea brilliant; the brain was deeply congested, and the lungs distended, but not engorged. When the body or part is exposed to its action for some time the sensibility of the skin is diminished, but if a wound or ulcer be exposed to its direct influence it reddens it, and produces a smarting pain.

TETRACHLORIDE OF CARBON.

Both the bisulphide of carbon and the tetrachloride were at one time employed as anæsthetics, and the first was described by the late Professor Simpson as a rapid and powerful anæsthetic; but after experimenting with them it was found that they both produced great depression, disagreeable visions, followed by giddiness and obstinate vomiting. The anæsthetic effect was found to be very transient, producing in animals both tonic and clonic convulsions.

They have fallen into disuse except as local anæsthetics in neuralgia and various local pains.

ACIDUM CARBOLICUM IMPURUM, U. S.

This is only employed externally or for disinfecting purposes.

ACIDUM CARBOLICUM—CARBOLIC ACID.

Pure carbolic acid is a crystaline solid, which becomes liquid by the heat of the hand. The dose is from one to two grains.

OFFICINAL PREPARATIONS, U. S.

Glyceritum acidi carbolici (acid ℥ij by weight; glycerine half a pint). Dose ♏v–x.

Unguentum acidi carbolici (ʒi to ℥i).

Suppositoria acidi carbolici (each gr.i.).

Auqua acidi carbolici (glycerite of carbolic acid fʒx, water q. s. ad ft. Oj.).

ANTIDOTES TO POISONING WITH CARBOLIC ACID.

Carbonate of lime, sodium or magnesia with lime water, and linseed oil, exvacuation of the stomach with stomach pump, with abundance of flour or starch and warm water.

CARBOLIC ACID AS A LOCAL ANÆSTHETIC.

Carbolic acid if applied to the skin at first is painful, but after a time this feeling passes away, and leaves the surface in such a state that even the actual cautery can be applied with impunity.

In some instances, I have simply painted the parts with a strong solution, or, when I desired to make one long incision, a line was drawn with a brush, charged with the liquefied crystals of the acid.

The following letter from Doctor Levis will speak for itself:—

My Dear Doctor:

"I have not any particular method of applying carbolic acid as a local anæsthetic, but have suggested varied uses of it. My application is always made with the deliquesced crystals of carbolic acid, sometimes liquefied by heat, and, more frequently, by the addition of a very small quantity of glycerine.

"One effective anæsthetic use is its application immediately after the actual cautery, and all pain is thus prevented. In cases of extensive burn of the surface and extremities, involving a very large area of skin, and where changes of the dressing would cause much suffering, I have directed that almost the entire body be simply wrapped in a linen sheet saturated with slightly carbolized oil. For this purpose linseed oil, from its viscid character, is probably the best.

"I always treat hydrocele with carbolic acid injection. This was my first original plan. The procedure is to *first* enter the *point* of a hypodermic syringe into the serous sac; then, with an ordinary trocar and canula, draw off the water. Then the liquefied carbolic acid is injected with the hypodermic syringe. The operation is *absolutely painless*, and much more certain in results than when tincture of

iodine is used. The point of the hypodermic syringe is *first* entered because such entrance would not be practicable after the fluid is evacuated. I inject two ordinary hypodermic syringefuls, equal to about ʒi of delequesced crystals. The inflammation which follows is not above the proper *plastic* grade, and the results are excellent.

"Truly yours,

"March 27th, 1879. "R. J. LEVIS.
DR. TURNBULL."

Cure of Hæmorrhoids by Carbolic acid by injections.—The following are the rules of Prof. Andrews:—*

1. Inject only internal piles.

2. Use at first dilute solutions, stronger ones only when these fail.

3. Treat one pile at a time, allowing four to ten days between the operations.

4. Inject from one to six drops (hypodermic syringe), smearing the membrane with cosmoline to protect its surface against dripping.

5. Confine the patient to bed the first day, and subsequently in case of any severe symptoms.

Poisoning by the external application of Carbolic acid.—Prof. Küster, at the last meeting of the Association of German Surgeons, entered the lists against the use of carbolic acid in antiseptic surgery. This assault has been supported by Langenbeck (*Berliner klin. Wochen.*, No. 28, 1878) and others. Children and delicate women are the chief sufferers from carbolic acid intoxication. The symptoms are, in the case of adults, nausea, vomiting and headache; but in children the effects are more severe,—the temperature falling below normal, the pulse being extremely weak and the body covered with a cold sweat, the phenomena of collapse.

It has been ascertained recently by Baumann, that if animals to whom carbolic acid had been previously administered are treated by sodic sulphate, a harmless compound of of phenol and sulphuric acid is formed. These results of experiments on animals have been confirmed by observations on man. Thus it has been found that the symptoms

* The St. Louis Medical and Surgical Journal, St. Louis, 1879, p. 356.

of carbolic acid poisoning are relieved by the administration of sodic sulphate. If this salt is given when the urine becomes dark-colored, it at once arrests the toxic phenomena, so that, if desired, the carbolic dressings can be renewed.

CARBOLIC ACID.

In 1864, two eminent French physiologists, M. M. Gratiolet and Lemaire, published a most interesting paper on the action of carbolic acid in arresting putrefaction ; and they have made the important observation that, whilst it does not interfere with chemical fermentation, such as the conversion of amygdaline into hydruret of benzoil, and the conversion of myronic acid by myrosyne, it completely arrests all vegetable and animal fermentations, which arise from cryptogamic life.

THERAPEUTIC PROPERTIES OF CARBOLIC ACID.

Ulcers.—To be applied in different degrees of solution, according to the character of the ulcer, carbuncle, and ill-conditioned sores.

Fistula.—To be applied by means of a pledget of patent lint or wax bougie carrying it to the bottom.

Hæmorrhoids.—As early as January, 1864, Mr. Thomas Turner states, in the *London Lancet*, "that the action of carbolic acid is mainly to corrugate, and therefore to obliterate, the sac of the piles."

Otorrhoea.—In fetid discharges from the ear, nose, throat, or rectum, it may be advantageously used, in the proportion of one part of carbolic to forty of water. Its action is first stimulating to the blood vessels, causing sanious discharges to become healthy pus. Even when there is caries, or ulceration of the bone, it effects healing of the part, and in necrosis it promotes exfoliation of the dead portion.

ANÆSTHESIA OF THE LARYNX.

There exists a vast difference in individuals in regard to the use of any form of instrument in the throat or in the larynx. With some there is no discomfort, and they will allow almost any manipulation without distress, gagging or vomiting. In the great majority of patients with diseased throat, larynx, or pharynx, the compressing of the

base of the tongue, or the introduction of the mirror to illuminate any part of these delicate organs, induces most distressing spasmodic action of the parts. It therefore becomes important to discover some means or remedy to prevent this difficulty in laryngoscopy and rhinoscopy.

Numerous agents have been suggested, but some of them are hazardous, owing to the risk of swallowing them, also because of the property which the mucous membrane has of absorbing such potent agents as morphia, chloroform, either by hypodermic medication or by inhalation.

From our own experience and experiments, we prefer the use of ice in small pieces, or the following preparation of tannic acid :—

℞. Acidi tannici, ℨii.
Glycerini, f℥iij.
Spts. vini rectif, f℥ij.

Mix by heat the tannic acid and glycerine, and when cool add the alcohol.

This mixture is to be applied with a soft brush to the parts for several days before the operation, as the constant introduction of the brush with the tannin upon it soon destroys the great sensibility.

The following are a few of the remedies which have been employed to produce anæsthesia of the larynx :—

A few inhalations of chloroform or ether have been recommended by Sir David Gibb. Prof. Turk proposes the application of a solution composed of three grains of sulphate of morphia dissolved in one drachm of concentrated acetic acid mixed with half an ounce of chloroform, to be applied by means of a soft brush before operating. Oertel and Cohen recommend the application to the larynx of a saturated solution of bromide of potassium, while it is also administered, by the mouth, in from one to five grain doses dissolved in water. More recently, Gibb has suggested the bromide of ammonium as a substitute for bromide of potassium. Prof. Schrötter, more bold than all the others, has published the following method :—

"The evening before the operation, the glottis is painted with pure chloroform about a dozen times, and an hour afterwards with a solution of muriate of morphia, gr. xij. to two drachms of distilled water. During the use of the morphia, the patient must not swallow his saliva (this is al-

most impossible); indeed, after each use of the brush he considers it prudent to let him gargle his throat with a solution of tannic acid. Early the next morning the operation can be undertaken. If, however, the patient be still sensitive, the whole proceeding must be repeated.

Prof. Gerhardt recommends as an anæsthetic to the larynx the painting of the laryngeal mucous membrane with a solution of colchicum.

LOCAL ANÆSTHESIA IN ODONTALGIA.

Toothache has numerous causes. The chief form in which local anæsthetics are employed, is when there is a very sensitive dentine, or exposure of the pulp, or "nerve of the tooth."

The first agent in point of importance is chloroform, alone or associated with tincture of aconite, the part, before making the application, to be perfectly dry, and the mixture placed upon a particle of absorbent cotton, and then pressed on with care, covering the cotton with soft wax. Prof. J. E. Garretson advises the chloroform to be mixed with the following agents:—

℞. Chloroformi.
Tinct. opii, āā fʒss.
Tinct. iodini.
Liq. plumbi subacet., āā fʒi.

This is applied by saturating a small piece of cotton and laying it loosely in the cavity.

For the toothache of little children, nothing has been as useful in our hands as—

℞. Alumnis ʒij.
Ætheris chlor. fʒj.—M.

To be applied on cotton after shaking the mixture.

A mixture of equal parts of chloroform and ether will answer the same purpose.

The following formulæ for the relief of toothache in the adult are strongly recommended—

℞. Chloroformi.
Tinct. benzoici āā fʒij.
Tinct. aconiti fʒss.—M.

Immerse a piece of cotton in the liquid, and introduce it into the cavity of the aching tooth.

℞. Chloroformi.
Creosoti (or diluted carbolic acid) āā ʒss.
Vini opii.
Tinct. benzoici āā fʒijss.—M.

To be introduced into the cavity of the aching tooth.

LOCAL ANÆSTHESIA.

FARADAIC ANÆSTHESIA.

The faradaie or interrupted galvanie current, or the two combined, have been at times employed to produce loeal anæsthesia. The experiments which I have made with this agency have impressed me with the idea that mueh of its influence was mental, yet eareful observers like Dr. Beard and others think differently, and reeommend it for operations in minor surgery, by directing a strong faradaic eurrent, should be directed through the parts.

ANÆSTHETIC ACTION OF BROMOFORM.

Bromoform (CHB^3) is produeed by the simultaneous aetion of bromine and eaustie potash on wood spirit, aleohol or acetone, also by the action of bromine on acetie, citric or malie acid; and by deeomposing bromine with alkalies. It is one of the impurities of hydrobromic ether.

Properties.—It is a limpid liquid, sp. gr. 2°.13, having an agreeable odor, and saecharine taste.

Dr. Rabuteau reported to the Biological Society, of Paris, some eases, showing that the applieation of bromoform to the skin produees anæsthesia without the revulsive and painful effects of the applieation of ehloroform.—*Gazette Hebdom., de Medecine et de Chirurgie.*

DR. B. W. RICHARDSON'S METHOD OF LOCAL ANÆSTHESIA.

Dr. Greenhalgh performed eæsarean seetion, in which loeal anæsthesia was employed by Dr. Richardson's method. The advantages of the local method were these:—(see p. 49.) Also *American Journal Medical Science*, July, 1876, p. 227.

LOCAL ANÆSTHETICS.

FREEZING MIXTURES.

The most common of these is a mixture of equal parts of snow or pounded iee and salt, which produces a degree of

cold of about 16° F. The salt causes the ice to melt, and the water dissolves the salt, so that both rapidly become liquid, in consequence of which a large amount of heat is absorbed. By employing it in an elastic bag, like that of Chapman, it will be found of great utility in all superficial incisions. If the snow or pounded ice is mixed with common salt in alternate layers, and placed in a gauze bag, a more profound impression may, in from fifteen to twenty minutes, be produced, and the tissues can be completely frozen if permitted to remain for one hour, and even a deep-seated tumor can be removed without any pain from the knife. It is well to examine the operation of the mixture, as the parts may become frost-bitten.

A much more powerful freezing mixture is formed by mixing together three parts of crystallized chloride of calcium and two parts of snow. The first will freeze water, the second will freeze mercury. Another mode, where ice cannot be had, is to mix together finely powdered Glauber's salt and the common muriatic acid of commerce. Nitre cools water in which it is dissolved, eight or ten degrees; one part of chloride of potassium dissolved in four parts of water, also cools it to the same amount.

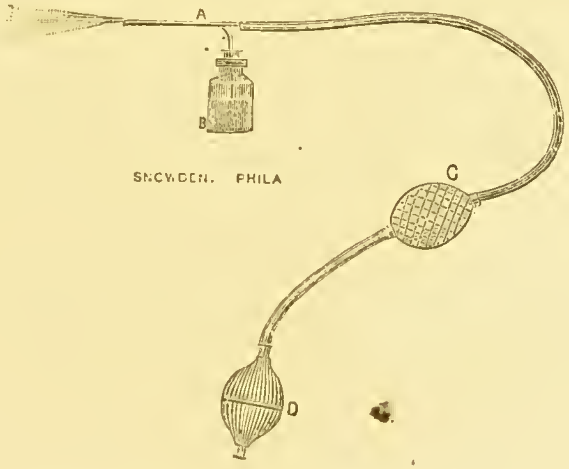

Fig. 27.

NOTE.—A piece of ice wrapped in a thin cloth, and applied to the part where the trochar is to enter, has been recommended in aspiration.

The form of apparatus, Fig. 27, is employed for local anæsthesia, produces so much cold by atomizing ether that it freezes the skin, and even the deeper tissues. It is used by Dr. B. W. Richardson, of London, or with Rhigoline as described by Dr. H. J. Bigelow, of Boston, or with gasoline as employed in Philadelphia. It consists of the elastic bulb D, which, with its valves, serve to force air into the elastic chamber C, which, alternately expanding and contracting, supplies a steady stream of air to the atomizing tubes A, which are of metal, one branch of which dips into the bottle B containing the ether, and the inner tube for delivering the ether runs upwards to the extremity of the outer tube. The ether must be directed on the surface, and must be the strongest, therefore free from alcohol and water. When the parts are properly frozen they become pale, shrunken, and tallowy looking, and when cut, like frozen fat.

When the rubber bag D is compressed by the hand, the reservoir bulb is filled, and a double current of air is produced; one current descending and pressing upon the ether, forcing it along the inner tube, and the other ascending through the outer tube, and playing upon the column of ether as it passes from the inner tube. The ether which is used in England for producing local anæsthesia is a mixture of amyl hydrate and anhydrous ether; it has a low boiling point and specific gravity, and is dangerous when inhaled. The best form of ether to employ for local anæsthesia is Dr. Squibbs' anhydrous, which is almost free from alcohol and water, and gives the best results.

EXTRACT OF EUCALYPTUS.

This agent is recommended as a local anæsthetic in dental operations and toothache. Apply one drop on cotton to the sensitive dentine just before excavating for filling.*

MORPHIA.

When sulphate of morphia is applied to the skin, even in the solution of three or four grains to the drachm, it has but little effect in relieving pain; but if the cuticle is removed,

* Boston Medical and Surgical Journal.

it then may be dusted over the surface with much better result.

Professor König says that he has combined the hypodermic administration of morphia with chloroform in a large number of cases with favorable results. It is seldom necessary to give more than from one-sixth to one-third of a grain.

If a solution of sulphate of morphia, one grain to the drachm of water, be made, and one-fourth injected by a hypodermic syringe, under a part to be operated upon, it will produce local anæsthesia.

CHAPTER X.

The legal responsibility of physicians in the administration of anæsthetics. Medico-legal relations of anæsthetics. Case in Philadelphia of a surgeon dentist. The important question whether chloroform can be administered for criminal purposes? Cases in France, England, and the United States. Dr. N. L. Folsom, R. M. Denig. Chloroform as a poison. Experiments of A. Martin Ewald, Hitzig, C. Bernard and Binz. Ethers; their action as poisons. Ether intoxication.

ON THE LEGAL RESPONSIBILITY OF PHYSICIANS IN THE ADMINISTRATION OF ANÆSTHETICS.

It is a noted fact that when anæsthetics are trusted in the hands of an educated and careful surgeon, the mortality from their use is reduced to the minimum. The individual who administers the anæsthetic should have nothing else to do; his hands, eyes and mind should be on *this alone.* In our hospitals clinical assistants should be instructed in the chemical, physiological and toxicological nature of anæsthetic agents, and after being thoroughly trained in their use and in the means of resuscitation, receive a certificate of competency. It is too often the case that valuable lives are placed, as it were, in the hands of young men who have no proper knowledge of their use, and who do not appreciate the great responsibility under which they are laboring. Such a powerful agent as chloroform or its compounds should be handled with skill, judgment and discretion, fully realizing that on the exercise of these depends the life of the patient. There is no doubt that many deaths have been caused through the want of this proper knowledge and experience. Who is at fault in this? It is, as a rule, the fault of the operating surgeon, who, in a general way, considers this as a secondary matter, and trusts the anæsthetic to any person who may be with him. To the experienced eye signs of danger are almost always evident, the disturbed, stertorous or shallow respiration, the pulse, the pallid or leaden hue of the skin, the fluttering heart.

We repeat it, that a physician or a surgeon in administering chloroform or its compounds, is responsible for the life of the patient, and it would be well for some of them if a law were enacted compelling them to employ the least fatal anæsthetic, unless some idiosyncrasy on the part of the patient did not allow of the use of such an agent, or one less dangerous. Again, in our navy, especially on board steamers, and in countries where the average temperature is 80° F. or over, chloroform might be allowed, but in the army, as well as in the navy, only in capital or very painful or extensive operations, this exception being enforced by a rule.

As well observed by Professor Hamilton,* of New York:—"The very annihilation of sensation itself impairs the health of the organs of the body; he had no question about it, and often, during the administration of these agents, nothing but God's providence prevents them from being plunged into eternity. But, on the other hand, there are many things to be said in favor of its use. The main lesson to be learned is *caution.*"

"Daniel S. Riddle, Esq., said, as regards the enactment of further laws on this subject, it was not necessary. There are sufficent laws already. The difficulty is in enforcing them. If there is carelessness on the part of the doctor, he should be held responsible. It is the same with lawyers. It belongs to the profession of medicine to say whether these agents have been carelessly used; and if they have been carelessly used, it is their duty to produce as well as indicate the person who uses these great powers carelessly. 'If we lawyers,' he remarked facetiously, 'find out that you are carelessly using these things, it is our duty to pitch in.'

"Mr. Coroner Ellinger thought it would be a hard matter to hold doctors responsible, because it is hard to state scientifically where the responsibility can rest. It ought at least to be shown that there was conscious negligence in the performance of duty. The condition of the patient should be taken into account, and that must be left to the discretion and knowledge of the attending surgeon. He thought

* Journal of Nervous and Mental Diseases. Chicago, Ill. Neurological correspondence.

that the medical student ought to be taught the danger of the agent he employs, how and when to use it judiciously, and he should be required to secure a certificate to the effect that he has been so instructed before being let loose upon the public. The public would then know that he possesses a knowledge of the agent which he employs. Besides, the physician would be conscious of a certain moral responsibility, for he held that the moral responsibility which every medical gentleman must feel is greater than the responsibilities placed upon him by the laws of the land."

"Jacob F. Miller, Esq., agreed with those who advocated care in the use of these agents. Man is living in the midst of dangerous forces, and will continue to use them, though of necessity many deaths occur. But in order to rest a case against the user, it is necessary to show negligence. Negligence is the gist of the action. The physician, surgeon, or lawyer, contracts for the ordinary skill and care of his profession. He does not contract for any extraordinary skill. The law does not hold him any more responsible than that. It would be unreasonable to do so, because few persons could safely practice their profession; and if any person should use anæsthetics, and the patient should die, that is not sufficient to charge him with the responsibility. He thought that all would admit that if a man not having the ordinary skill of his profession, should by unskillful administration of anæsthetics cause the death of the patient, he should be prevented from doing further damage by a suit for malpractice. Would it not be better to stop him by such procedure? Shall a man be allowed to use such dangerous forces just as he pleases—let the consequences be what they may? People consult physicians because they say they have the requisite skill to use these things. They hold themselves out to the community as having this skill, and they ought to possess it; if they do not, and harm results from it, they ought to be held responsible. The coroner says that physicians are actuated by moral responsibility, which is just no responsibility at all. The quack will go on with his practices until he is stopped by the law. Where is his moral responsibility? What does he care? His practices only go to show that he has no moral responsibility. *That lawyers should check such practices is due*

to the profession, to the public and to God. But before they take a case of malpractice, they ought to be convinced that there is malpractice. It may be all very well to say that negligence is the gist of an action. If it cannot be shown that there is negligence, the case should not be taken; for when the case arrives at the courts, you must show that the defendant is guilty of neglect, and that is done by calling upon a physician who is able to say where negligence has been committed, and that he is guilty of it. This evidence is necessary; lawyers cannot get along without it."

"Mr. Max F. Eller spoke of the *fact* that, for any action, as many 'experts' could be obtained by one side as the other, provided enough money is paid for such expert testimony. Some will say the patient should have been notified of the danger; others that he ought not. Some will say the chloroform killed him; others, not. For that reason he thought that before making any more laws regarding the proper administration of anæsthetics, those which already exist should be administered in a better manner, and physicians should be a little more careful how they administer anæsthetics.

"Mr. Eller referred to the popular fallacy that chloroform could be used successfully for the purpose of affecting robbery. He thought that that delusion ought to be dispelled, for the time between the actual administration of chloroform and the period of annihilation of sensation is sufficiently long to render the accomplishment of the object impossible. Such a plea is used by criminals to shield themselves from the consequences of their own crimes."

A correspondent of the *Societe d'Hygiene et de Medicine Legal*, having been interrogated as a judicial expert as to "whether the employment of narcotics in the liquid or gaseous state can produce an anæsthesia so profound that violation of the persons to whom it has been given may be perpetrated without awakening them," gave an affirmative answer.

M. Dolbeau, apropos to this judgment, made a series of researches, the results of which were laid before the society at a recent session. He limits the question to the employment of chloroform, and starts with the following proposition:—

"*Can chloroform in vapor be administered to a person who is sleeping naturally, to the production of anæsthesia, without awakening him?*"

In M. Dolbeau's experiments the chloroform was given in the usual manner, on a cone held an inch or so above the nostrils, so as to enable a constant view of the countenance.

In the first series of experiments three patients out of four were wakened by the chloroform inhalations; in the second series, four out of six; in the third, only three out of nine.

It is not without interest to observe the increasing proportion of subjects anæsthetized; the manual dexterity acquired by the experiments is not without influence upon the results obtained. Accordingly, as a result of his experiments, M. Dolbeau believes himself authorized to formulate the following conclusions:—

Scientifically, it is difficult, but often possible, to cause insensibility by means of chloroform in persons who are sleeping a natural sleep. Certain precautions—the employment of a perfectly pure agent and experience—are also conditions which favor the attempt at anæsthesia.

It is probable that certain subjects are absolutely refractory—that is to say, that it is impossible to anæsthetize them without taking every precaution. Others, on the contrary, particularly young children, submit easily to anæsthesia, without having been awakened by the irritation produced by the anæsthetic agent in the air passages.

From a criminal point of view, it is certain that chloroform, administered to sleeping individuals, may facilitate the perpetration of certain crimes. It is, however, probable that the conditions favorable to anæsthesia are rarely found on the occasion of criminal attempts. In justice, the expert should declare that it is possible, but not easy, to render a person who sleeps, so insensible, by chloroform that the said person might become the victim of any violence.—*La Tribune Medicale*, No. 323, 1874.

The responsibility attending the use of anæsthetics is of great importance to medical men, as frequently their personal and professional reputation is at stake; it is therefore always better in the administration of an anæsthetic *to a female* to have some reliable person present. This is especially necessary when ether or chloroform is employed.

During the early period of my medical career, soon after graduating, I had in my Quiz class a young ambitious dental surgeon, one of the most gentle and amiable of men, who was desirous of obtaining the medical degree, which he ultimately attained. Soon after this the man was married, and settled in this city, and acquired a large business. At that time it was common for the dentist to administer the anæsthetics in their office, in the extracting of teeth, etc. He had a young female patient to whom he administered chloroform alone, and who afterwards stated that he had taken improper liberties with her person during this state. This case caused great excitement in our city, and the public sympathy was with the young female, and a suit was instituted in which damages were claimed. The case was argued by distinguished lawyers on both sides, and voluminous testimony taken. The judge charged the jury, and the sentence was ten years' imprisonment. Subsequently the sentiment of the community changed, and it believed that it was all the result of her vivid imagination, and that she was laboring under a delusion. The majority of physicians and dentists signed a petition, and the sentence was remitted, but his professional prospects were ruined.

It is stated by Taylor,* "That the vapors of ether and chloroform have been criminally used in attempt at rape. In a case which occurred in France, a dentist was convicted of this crime upon a woman to whom he had administered the vapor of ether." Now this may be just such a case as the one in our own city. Ether, from its disagreeable taste and irritating vapor, would be much more difficult to administer forcibly and against the will of a patient. The numerous stories of anæsthesia by simply placing a few drops on a handkerchief under the patient's nose or mouth, are in the majority of cases perfectly absurd, as the shortest time required to bring a patient fully under the influence of either of these drugs, even when forcibly held in contact, is from two to ten minutes, and if subsequent rough handling takes place the patient is at once roused up to make re-

* Taylor's Medical Jurisprudence, English edition, London, 1865, p. 1006.

sistance by struggling. We were once called to a woman who had been in the habit of employing chloroform by inhalation from a small bottle to cause sleep; she accidentally when in a drowsy state let the open bottle drop on the pillow, and its contents saturated the covering, and she with her face in it. But instead of making her sleep soundly, it produced most distressing nausea, and her family were awakened by her efforts at vomiting, and so her life was saved, she not being able to arouse sufficiently to get rid of the offending matter, and which would have lodged in her trachea, or the contents of the stomach might have been brought into the bronchial tubes by a deep inspiration, and thus have caused suffocation.

The former case in Philadelphia settled the important point in the minds of medical men of this city that this incomplete unconsciousness does not coexist with complete motor and sensory anæsthesia, and therefore anæsthetics are employed without any fear in all important operations. These observations are in part corroborated by two learned authors in a recent and most admirable work* on medical jurisprudence, in which they state:—

"A question of some importance to the medical jurist naturally occurs here, namely, '*Whether chloroform can be administered for improper purposes?*' We know, however, that comparatively, the insensibility from chloroform (and more slowly from ether) vapor is only slowly induced. It would be difficult, therefore, to administer chloroform forcibly and against the will, while, of course, the stories of immediate anæsthesia produced by it are but idle fables. Still, it might be administered to persons asleep without much difficulty (*Lancet*, October 5th, 1872, p. 514, and October 12th, 1872, p. 549), and this seems the only possible condition under which it could be conveniently used for improper purposes, unless considerable force was employed to prevent the person struggling, which, under ordinary circumstances, would be an almost insurmountable difficulty to its use."

The following case (reported in the *Philadelphia Medical Times*, December 22d, 1877), which quite lately occurred in

* Forensic Medicine and Toxicology. By W. Bathhurst Wood, M.D., F.R.C.P., and Charles Maymott Tidy, M.B., F.C.S. Lindsay & Blakiston, 1877, p. 457.

England, more completely confirms our own observations and experiments on this important subject:—

"A case of the utmost importance to the whole profession, not in Great Britain only, but everywhere, was tried before Mr. Justice Hawkins, at the assizes at Northampton, on the 9th of November. It was a charge against a surgeon's assistant of criminal assault—of rape upon a patient when under the influence of chloroform. If there is a dastardly crime, it is to take advantage of a woman's helpless unconsciousness to violate her person. And so the magistrate thought, who sent the accused to jail on the 14th of September, declining to hear anything in his favor, and resolutely refusing to accept bail. The charge was that a married woman, named Child, went to the surgery of her family medical attendant to have her teeth operated upon. She had been there a day or two before, but the attempt to put her under chloroform then failed. A second attempt was rather more successful. She evidently had some peculiarities or idiosyncrasies in relation to chloroform, for he gave it for an hour and yet she was never sufficiently under its influence to admit of the operation being performed. She was accompanied by a friend—a Miss Fellows. At the end of the hour Miss Fellows went out of the room and saw Mr. Child. In a quarter of an hour Miss Fellows returned. The prosecutor maintained that on Miss Fellow's return she was quite conscious, but unable to speak. Finding it impossible to perform the operation, the accused accompanied the prosecutrix and her friend home. So far Mrs. Child had been unable to speak, but shortly after the accused left the house she complained to her husband that he had taken advantage of the absence of Miss Fellows to assault her criminally. Next day, when the accused called, he was told about what she had said, and he replied that she was laboring under a delusion. Under cross-examination Mrs. Child said that she told the accused that if he would admit the offence and quit the town (Birmingham) she would forgive him. This the accused declined to do, denying that he had committed any offence. He was then given in custody. The prosecutrix stated that the offence was perpetrated immediately after Miss Fellows left the room; that the prisoner went upon his knees and then assaulted her. Miss Fellows

stated that on her return she found Mrs. Child in precisely the same position in the chair which she occupied when she went out of the room. Such were the facts of the case. It was quite clear that there had been either an assault committed, or that the woman was under the influence of a very pronounced delusion. The whole of the accused's conduct was in favor of the latter hypothesis. But in such a matter, where no third person was present, the statement of one of the two parties concerned must be taken. When a woman whose character was apparently without blemish (for in cross-examination no attempt was made to call her reputation in question) makes a definite charge against a man of assaulting her under circumstances which permitted of such an assault, the law could only send the case to a jury. In the meantime the unfortunate surgeon's assistant was sent to prison.

"When the case came to be tried a large number of medical men of repute came forward voluntarily to aid the accused's defence, and did this quite gratuitously. The chief witness for the defence was Dr. B. W. Richardson, F.R.S., whose celebrity is world-wide. As is well known, Dr. Richardson has studied anæsthetics very carefully and for many years. He stated that there were four stages or degrees in which chloroform operated. The first stage was that in which consciousness was not lost; there was resistance and a desire for air. In the second, consciousness is lost, but the operation is impossible, the patient screaming, often without provocation. The third stage is that of complete unconsciousness, and where all rigidity is lost. This is the stage which permits of operation. In his opinion the patient was in the second stage; the third never having been reached. He stated that in his own experience he had known persons in this second stage to have delusions as to what had taken place during that time. He related a number of cases, and stated that the fact of such delusions being induced by chloroform was one of the earliest objections raised to its adoption. He related one case where the patient, a female, was being operated upon by a dentist, and alleged that the dentist criminally assaulted her. And this she persisted in, though her father, her mother, Dr. Richardson, and the dentist's assistant were all present throughout the whole

time. She persisted in her conviction long after the effects of the chloroform had passed away; and Dr. Richardson said she was probably of that belief still. This evidence of Dr. Richardson's was corroborated by the experience of Dr. Hawksby, of London, and by Dr. Saundby and Mr. J. F. West, of Birmingham. The judge asked the jury if it was necessary to sum up, and they replied it was unnecessary—they were already agreed upon a verdict of acquittal. Mr. Justice Hawkins pointed out that such a verdict would not be the slightest imputation upon the absolute sincerity of the prosecutrix, who, no doubt, firmly believed every word of what she had said. He then congratulated the accused upon having had an opportunity of fully vindicating himself from the charge preferred, and said that the verdict of acquital did not mean that there was insufficient evidence, but that the accused was entirely cleared of any imputation in respect to the charge preferred against him. There could be no doubt the prosecutrix labored under a delusion. The accused was then discharged from custody, having been in prison two months for no offence. It is not merely that this unfortunate man was imprisoned for two months for an imaginary offence, but that any man who is present when a woman is being put under chloroform is liable to have the same charge brought against him, that gives this case its gravity and importance.

"Such being the case, it becomes necessary that a little more should be known amidst the profession, as well as the laity, as to the occurrence of erotic sensations in woman. The subject is not a very pleasant one, but that is no reason why it should not be investigated. If it is a fact, and there is no doubt about this, that women when being put under chloroform are liable to those erotic sensations which they experience from sexual intercourse, the sooner the fact is generally known the better. It is just the mystery which surrounds such facts that permits such a monstrous hardship as that mentioned above to be a possibility at all. Of course it is obvious enough to any one that it is a delicate matter to inquire into the subjective sensations of women. But if these subjective sensations take the practical form of a charge of rape, two months in jail, and a trial by jury, they pass from the domain of sentiment and enter that of stern

reality. Few, comparatively few, of the profession seem to be aware that women are subject to conditions and sensations identical with those associated with the sexual act, which arise quite subjectively and without any extrinsic stimulus. The delusion of St. Catharine that the devil visited her every night and enjoyed her person when she was asleep and could offer no resistance, is no unique experience, but one common enough to woman. Every one familiar with asylum work knows that a certain percentage of women patients have the delusion, among others, that the medical superintendent comes nightly to their bed and violates their person during sleep. Of course there is no foundation of any kind for such a delusion, except the subjective sensations of the woman herself. How strongly such a delusion, however, may be fixed in a woman's mind is evidenced by the case related by Dr. Richardson, where the woman persisted in her belief though her own father and mother, as well as others, were present, and where such assault was physically impossible. Such being the case, it behooves every man who is to be present with a woman when she is to be placed under chloroform to see that there is at least one other person present, and that, too, the whole time, without intermission, during which the woman is under the influence of chloroform, and that such other precautions be taken as will preclude the possibility of such a charge being raised. That Mrs. Child charged this unlucky man in good faith need not be questioned for a moment. She was far from being hostile to him, for she offered if he would avow his guilt and leave the town she would forgive him. The charge was not pressed from any rancorous spite; that is abundantly clear. But it is equally clear that something had occurred to that woman which she interpreted into the sexual act, and that this was so firmly fixed in her consciousness, that it could not be dislodged. It becomes necessary then that the subjective sensations of woman should be investigated, and made the subject of scientific observations; and seeing that they exist, they must have a scientific value; and that no prudishness should prevent attempts being made to ascertain what the actual facts are, and what is their interpretation."

The following is the experience of Dr. N. L. Folsom, of Portsmouth, New Hampshire, in the same line:—

"In 1854 a clergyman's sister came to my office for the purpose of taking ether and having a tooth extracted, and brought her brother's wife with her. I began to administer the ether to the patient, and whilst renewing it she got away from me, and seemed alarmed and offended. I did not attempt to compel her to breathe any more ether, but urged her to take it, and so also did her brother's wife, but she would take no more. She had the impression, so her brother told me, that I attempted to violate her, and that his wife assisted me. It was a long time afterward before she would fully give up that she was mistaken in the matter."*

We are almost certain, after a number of careful experiments, that chloroform and ether can be administered in sleep, so as to produce the first stage of anæsthesia, and can be carried to full completion or total unconsciousness. Still this is rare without disturbing the patient's stomach, causing nausea, or irritation of the lungs, with risk of sudden death, by its dense vapor, and thus rousing him or her to consciousness, or a condition in which the patient can resist its influence if the party is willing to make the effort. Another important point is that loud talking or handling, even in some cases the slightest touch or pain in any way, will cause the patient to start and rouse him to resist. In the case of ether the patient can almost always see indistinctly, and in some instances is able to talk during the anæsthetic state.

Dr. R. M. Denig,† of Columbus, Ohio, in an article on the Medico-legal Relations of Chloroform, propounds the following queries:—

"1. Can they be administered successfully to persons during natural sleep without awakening them?

"2. Can they be forcibly administered for criminal purposes in opposition to the will of the person to whom they are given?

"3. Can a person give competent testimony as to what occurred during the anæsthetic state?"

His general conclusions are, that it cannot be used successfully for felonious purposes, and that a person in the

* Medical and Surgical Reporter, January 12, 1877.

† Ohio Medical Recorder, January, 1877.

anæsthetic state is not a competent witness. He gives the following example:—

"Most of you are cognizant of a transaction which took place in our city a few years since, and which for a time produced the wildest consternation. Two employés in the service of an express company were said to have been chloroformed during sleep, the keys to the safe abstracted from their pockets, and the safes robbed of their valuable contents. A sponge which bore the decaying fumes of chloroform was found near the head of one of the messengers, etc. The whole thing was well gotten up, and was calculated to deceive even the most incredulous, and excite a sympathy in behalf of persons who had not only been robbed, but nearly strangled. In less than a week, however, the possession of large sums of money led to the arrest of the supposed chloroformed individuals, and to their incarceration in the Ohio State prison."

SOME PHENOMENA OF ANÆSTHESIA BY PROTOXIDE OF NITROGEN.

Mr. F. W. Braine, in a paper on this subject (*British Medical Journal*, January 23d, 1869), observes: "It is curious to remark how often, as unconsciousness comes on, the ruling idea is one of noise and motion combined. Some patients think they are seated in, or running after, an omnibus, but many more imagine themselves in a railway carriage, traveling faster and faster, till they suddenly seem to enter a dark tunnel, and then all is a blank to them. Sensual emotions are not unfrequently excited in both sexes. A man who had been married about three months stated, on awakening, that he had been dreaming of his wife; and an unmarried hysterical girl certainly gave evidence, by her movements, that she was quite aware of one of the duties of married life; and moreover, in this case, the idea was still present when she was able to speak, for she addressed the administrator in terms far fonder than the occasion warranted, while another girl, who had behaved in a similar manner, said, 'I hope I have not said anything naughty.' Both of these cases brought forcibly to one's recollection many trumped-up cases of felonious assault, and how extremely inadvisable it is to have recourse to anæsthesia without a third person being in the room."

"At a recent meeting of the Odontological Society, it was stated that the nitrous oxide had been administered in a few cases of pregnancy, but delivery not having at that time taken place in any one of these cases, the condition of the fœtus *in utero* was unknown. A lady, one of the above cases, whom I put fully under the influence of the gas twice during the eighth month, has just been confined with a fine healthy boy; so that, in this case at least, the gas cannot have interfered with the nutrition of the child, for it weighed at birth eleven pounds and a half.

"When administered to a girl, aged nineteen, with cavities in the apices of both lungs, the patient was insensible at the end of forty-five seconds. The respiration suddenly became very shallow and panting, while instead of the rosy hue which generally appears over the face and lips on the removal of the face-piece, the lips and face became more dusky before the red tint appeared; the pulse was not affected, but the respiration, for more than half an hour afterwards, was very shallow and hurried."

CHLOROFORM—ITS ACTION AS A POISON.

Chloroform is an irritating poison. In a case quoted by Taylor,* an individual swallowed four ounces. He was able to walk a considerable distance after taking this large dose, but subsequently fell into a state of coma. The pupils were dilated, the breathing was stertorous, the skin cold, pulse imperceptible, and there was general convulsions. He recovered in five days. (*Medical Gazette*, vol. 47, page 675.) A second case reported swallowed nearly two ounces and recovered; and a third swallowed two ounces, but he died in six hours afterwards. In this case the pupils were fully dilated, the breathing was stertorous, and the skin covered with a cold perspiration. On inspection, the lungs were found much engorged with blood, and there were some apoplectic effusions in these organs. The stomach was slightly inflamed in patches, and the mucous membrane was softened. (*American Journal Medical Sciences*, October, 1866, page 571.) A physician æt. 57, swallowed three ounces of chloroform. He immediately began to

* On Poisons, Philadelphia, 1875, page 618.

stagger, as if intoxicated. He vomited and sunk into a deep stupor, and was in a state of complete anæsthesia. His skin was pale and tolerably warm; the muscles were relaxed, the breathing short, and the action of the heart weak and intermittent. In about fourteen hours sensibility returned. Acute gastritis ensued, with rapid collapse, and proved fatal in twenty-nine hours from the time the chloroform was taken. (*American Journal Medical Science*, January, 1870, page 276.)

Treatment.—In poisoning from liquid chloroform, the stomach pump and emetic should be resorted to. If evidence of suspension of the action of the heart (syncope) exists, there should be a free exposure of the face to a current of air, compression of the chest and artificial respiration, with warm applications to the chest, with active friction and stimuli externally and by the rectum. The poles of a galvanic battery applied to the chest and side of the neck with sponges dipped in hot water should be used. Spirit of ammonia aromata has been found useful when injected hypodermically, and strychnia in the same way, to act upon the respiration. This must be given in minute doses, and great care must be given to the gastritis and disturbance of the liver, which are apt to follow in the convalescence of the patient.

ETHERS ADMINISTERED INTERNALLY.

Ethers as a class are poisons, and if taken into the stomach in very large quantities will produce death. Still they can be employed for a long period without dangerous action on the heart and respiration. The habitual use of ether ruins the digestion and causes chronic disturbance of the nervous system (see cases subsequently reported), and this has been confirmed by E. Martin Ewald, of Berlin.

In dogs, whose brains are exposed, the vigorous inhalation of ether soon renders that organ completely insensible to the electrical current. (Hitzig.)

After introducing ether into a dog's stomach, Claude Bernard observed an immediate secretion of a large quantity of pancreatic juice. There was vascular congestion of the intestine, and its secretions became more abundant, while absorption was accelerated. The chyle vessels were strongly

injected, which must be explained by the abundance of pancreatic juice present in the bowel (Binz), when fat in fine subdivision is introduced, and the consequently increased facility with which it could be absorbed.

If the blood be examined (Binz) after twenty drops of ether have been taken, the colorless corpuscles in it are found to be twice as numerous as usual. It is probable that here also ether has a direct action on the abdominal glands, and especially the spleen.

ETHER INTOXICATION.

"A few years ago there was published in the *Reporter** the 'confessions of an ether inhaler,' a member of our own profession, for whom it subsequently became our sad duty to sign a certificate of insanity.

"We are reminded of this by a paper in the London *Medical Record*, by Dr. Ewald, of Berlin, on a somewhat similar case. It is that of a man aged thirty-two, who was lately admitted into the Charité Hospital, under Professor Frerichs, suffering from general debility and trembling of the muscles. On inquiry, it was found that he was notorious in Berlin for intoxicating himself with ether, his abuse of which had reduced him to his present miserable condition. He was originally temperate, and had been a university student, passing all his examinations with credit; he was, however, of a mystical turn of mind. Unfortunately, a little more than nine years ago, there fell into his hands a medico-popular treatise, in which the use and effects of ether, used medicinally, were described, and a glowing account was given of its effect in quickening the creative power of the mind. He procured about two or two and a half ounces of sulphuric ether, and inhaled it from a handkerchief; the result being to produce insensibility for about a quarter of an hour, during which time he imagined that he lived for an indefinite time, and traveled over whole worlds. This condition, however, he was not again able to induce in so high a degree. Becoming gradually more and more addicted to his habit, he no longer confined himself to indulging himself in his own room, but with his etherized handkerchief before his face, he wandered through the

* Medical and Surgical Reporter.

streets, purchasing small quantities of ether at the druggists' shops, until, at last, he became so great a nuisance to them that many of them closed their doors against him. He was also turned out of his lodgings, on account of the annoyance produced by the smell of his breath, and became a houseless wanderer, reduced in means and in health. In the hospital there was no indication that his mind was affected; his memory was not impaired; his style of speaking was fluent. On one occasion an attempt was made to produce complete anæsthesia. For this purpose more than seven ounces were required; the ether being given by an inhaler, and loss being prevented by closing in the apparatus with cotton-wool. No sooner, however, was the inhalation stopped, than the state of insensibility passed off. He was then allowed to take the ether in his own way, by inhaling it from a handkerchief. Given in this way, it produced a stage of excitement, during which he danced about the room, talked nonsense, and appeared much pleased, but there was no true narcotism. It was not thought justifiable to subject him to other experiments with ether, as it was desirable to break through his habit. It is interesting, that his susceptibility to the action of cannabis indica was not impaired. This drug was given as a substitute for ether, and on the first occasion, too large a dose having been given, the result was the production of phantasms, such as are induced by the smoking of hasheesh."

The late Dr. Morgan, of Dublin, states that ether is employed in certain portions of Ireland as a substitute for whiskey.

A case has come under the writer's notice in which a patient began the use of sulphuric ether in teaspoonful doses, as a nervine ordered by a physician, and ultimately increased the dose to one pint per day. When informed of its injurious character, she had lost her appetite, and suffered gastric disturbance; she gradually diminished the quantity and was able to give it up after a month or two. The only effect it had upon her was to give her apparent strength to go on with her teaching of music. Large quantities of ether have been taken internally, and, so far as we have been able to learn, no death has yet occurred from its use in this way.

CHAPTER XI.

GENERAL CONCLUSIONS.

Alcohol preparations. Treatment of poisoning by Ether. Inhalation and internal administration. Precautions in its inhalation. Bichloride of Methylene. Hydrobromic ether; use and new mode of preparation; conclusions. Ethidene dichloride. Oxygen, hydrogen, and nitrogen gases. Dr. Gray's experiments with oxygen gas. On the use of anæsthetics, especially Chloroform, in dental operations. Treatment of chloroform poisoning. Chloroform and Chloral in poisoning by Strychnia. On the choice of anæsthetics. Another death from Chloroform. Bibliographical list of papers and works on anæsthetics. The Metric system.

ALCOHOL—SPIRIT OF THE SPECIFIC GRAVITY 0.835, U. S.

OFFICINAL PREPARATIONS, U. S.

Alcohol dilutum.—Diluted one-half with water.

Alcohol fortius.—Spirit of the specific gravity 0.817.

Spiritus vini gallici (brandy).—About fifty per cent. of alcohol.

Spiritus frumenti (whiskey).—About fifty per cent. of alcohol.

ANTIDOTES.

The treatment of poisoning by any form of alcohol, or its compounds, is removing all the spirit from the stomach by an emetic of mustard and hot water, or if the stomach will not act employ stomach pump. Cold water or ice to the head, strong coffee, stimulants, galvanic current, and artificial respiration.

POISONING FROM ALCOHOL.

In chronic alcoholic poisoning withdraw stimulants, and substitute the following mixture, to be given about the time of the strong craving for a drink.

℞. Potassii bromidum, ℨij.
Tinctura capsicum, fℨss.
Syr. limonis.
Aqua menthæ pip., āā℥j.—M.

Sig.—A tablespoonful about twelve o'clock M. in water, with a cracker. Abundance of good, rich, well-seasoned food, and the mixture at bed time, to procure sleep.

ETHER.

OFFICINAL PREPARATIONS, U. S.

Æther. fortior.—Specific gravity 0.728 for inhalation and internal administration.

Spiritus ætheris compositus. Hoffmann's anodyne.

PRECAUTIONS.

Ether should never be inhaled after a full meal, not only to avoid the annoyance of vomiting in the midst of the operation, but also the danger of asphyxia by some of the vomited matter dropping or running into the larynx and trachea. If nourishment is necessary let it be of a liquid character. Perfect quietude should exist around the patient. Clothing should be perfectly loose so as to not interfere with respiration. *False teeth should always be laid aside.* The inflammability of ether should be remembered as well as the density of its *vapor* (2.568), for this density, although insuring comparative safety *around* a light, will cause it to ignite if the light be even some distance *under* it. Examine and record condition of the patient's heart and lungs, and in suspicious cases all the organs. In holding a patient down during the stage of excitability, do so firmly, at the same time allowing the limbs as much freedom of motion as possible. Being held in a vice like grasp frightens the patient, and has caused dislocation, and even fractures.

DANGERS IN THE ADMINISTRATION OF ETHER.

Ether is not altogether free from danger, but *it always gives warning* before it causes the death of the patient. The ultimate effects of anæsthetics show that they are all depressing agents. It will produce entire insensibility in all cases, with little or no risk, *if administered by a competent person.* The countenance should be watched, and the difficulty of breathing promptly attended to. The moment the face assumes a purple, dusky, or extremely pale hue, remove the inhaling apparatus and admit fresh air. If not sufficient, draw the tongue forward with a pair of artery forceps, or by a towel wrapped around it, at the same time keeping the mouth open by pressing on each side of the jaw with bent thumb and index fingers, pressing the cheeks between the teeth or gums. If the arrest of respiration be due to the pres-

ence of vomited matter in the larynx, the head should be turned quickly and lowered below the level of the table. This precaution should always be taken when vomiting occurs. If these means should fail, Marshall Hall's method of artificial respiration should be employed, or a small air-bag or bellows with a nozzle might be used, inflating the lungs, then withdrawing the instrument and pressing firmly but steadily on the chest, this being repeated not more than *eighteen times per minute.* An enema of equal parts of brandy and luke-warm water should be given at the same time. A towel soaked in ice-water slapped two or three times on the chest and face, will sometimes succeed where other means have failed.

ADMINISTRATION.

An inhaler is made by folding a towel into a large cone or bag, and then placing a large sponge in its apex. Ether is then sprinkled upon it with a free hand, half an ounce or more at a time, and repeated if necessary by renewing the supply of ether. The lower part of the face, mouth, and nose, is covered with the cone, so as to exclude most of the air, and allow the patient to fill his lungs with more or less diluted ether vapor, depending on the care with which the cone is applied. There will be at the beginning of the inhalation attempts to struggle, which are to be gently restrained. Quiescence gradually comes on, the patient passing into profound insensibility. If, however, the face become very pale or livid, the inhaler should be set aside until this condition disappears. The patient is considered as ready for the operation when the arm, when raised, will fall as if paralyzed, or when the orbicularis palpebrarum muscle will not respond to irritation, or the conjunctival surface of the eye can be touched with impunity. Early stage of anæsthesia by ether pupils are contracted, but when there is complete anæsthesia the pupils become dilated, and the respiration is slow and deep.

If the operation is to be a prolonged one, when the patient is fully under the influence of the anæsthetic, holding the inhaler one-half inch or so from the patient's face will allow enough air to reach the lungs to insure perfect safety, and enough ether to hold him completely under its influence.

BICHLORIDE OF METHYLENE.

Introduced by Prof. Richardson in 1867. A colorless fluid, having an odor much like that of chloroform. Pleasant to inhale as a vapor, producing very little irritation of the fauces and air passages. From its easier evaporation, it requires freer administration than chloroform, and because of its denser vapor, less quantity than ether. Six deaths have occurred from its use. It has many of the dangerous qualities of chloroform, and death results from syncopé, with dilated pupils.

HYDROBROMIC ETHER.

This ether has been employed by me, and in several cases with success, since my first report on page 79, and in the case somewhat delayed (see Smith case); also a case of successful removal of diseased toe-nail, by Dr. Drake of this city, and a cyst of the hyoid bone, by Dr. S. W. Gross before the class at Jefferson College Hospital. The ether was given by myself and the pulse was under the care of Dr. Levis, who kindly sent me the following letter in reference to it, when I desired an expression of his opinion in regard to it.

"April 28th, 1879.

"My Dear Doctor:—My impressions of the new anæsthetic were decidedly in its favor. The circulation was not depressed, mental excitement did not occur, and respiration continued to be normal.

"I would be much gratified with the opportunity of seeing more cases of its use. Where can I obtain a supply of it? "Truly yours,

"R. J. LEVIS."

I find that hydrobromic ether exposed to the air and light changes in color, becoming at first yellow, then yellowish-brown. But this does not interfere with its anæsthetic qualities, but produces a more aromatic or peppery taste; it should therefore be free from alcohol and water, and kept from the light. Dr. Greene, before leaving for Paris, furnished me with his method of preparation, which I have appended, so that any careful pharmaceutist can make it:—

"Coarsely powdered potassium bromide is heated with sulphuric acid, diluted with its volume of water in a flask or retort, and when vapors of hydrobromic acid begin to be

disengaged, alcohol is allowed to flow in slowly, as in the preparation of ether. Ethyl bromide distills over with water and some alcohol. It is decanted, agitated with water to remove alcohol, and dried with potassium carbonate. It needs no other purification."

IDEOPATHIC POST-AURICULAR PERIOSTITIS, OPERATION AND RELIEF UNDER HYDROBROMIC ETHER.

REPORTED BY W. D. FEIDLER.

In case No. 15 (page 76), before reported, it was necessary to perform an operation, and the following notes were made by Mr. D. W. Feidler, one of my assistants at Jefferson College Hospital ear clinic. "The patient at No. X took ℥ij of hydrobromic ether by inhalation in the presence of Prof. S. D. Gross, and the result was that the patient was only drunk, and would not inhale properly (as observed Dr. Gross, 'he was as stiff as a poker'). The nurse then brought a fresh supply, and by the use of ℥j he was fully under its influence in forty seconds, when he was as limber as a rag. Dr. Turnbull made a long incision down to the bone and into the body of the sterno-cleido-mastoid muscle without the slightest indication of pain, with very free hæmorrhage, but no pus and no roughness of the bone, but with great relief to the patient's head and pulse. The temperature being reduced from 102° to 99°. Patient fully recovered after six weeks in the hospital."

Remarks by Dr. Turnbull.—This patient was in the same condition as the one before referred to. (See page 28.) When pure ether was administered by Dr. Allis, the patient consumed eight ounces and was not relaxed, and the doctor had to employ chloroform before I was able to perforate the mastoid cells.

Conclusions in regard to hydrobromic ether as an anæsthetic in twenty-five cases, being an additional four cases since my report on page 79.

	Minutes.	Seconds.
Shortest time taken to place a patient under its anæsthetic influence, .	0	40
Longest time, ...	6	40
Longest time under its influence, .	60	0

Largest quantity consumed, *eight ounces.*

With one patient out of the new cases there was vomiting, as the patient had taken dinner before the operation. This was the little girl operated on by Dr. Samuel W. Gross.

ETHIDENE DICHLORIDE.

The Scientific Grants Committee of the British Medical Association have received from a special committee a report, in which it is claimed that this anæsthetic presents all the advantages of ether, without any of its disadvantages. Mr. Thos. Bird, M. R. C. S. E., thinks it a good anæsthetic for children.

OXYGEN

Is not a true anæsthetic.

OXYGEN, HYDROGEN AND NITROGEN.

It has been found that animals are capable of respiring oxygen gas for a long period of time without other apparent effect than increased liveliness and augmented appetite. Oxygen gas, when respired by man, to the extent of twenty-nine to thirty quarts, produces little effect. Any insensibility produced by the inhalation of nitrogen or hydrogen and rarefied air, is due to deficiency of oxygen, of which asphyxia is the result; or perhaps it may be produced by the analgesic effect.

OXYGEN GAS AS AN ANÆSTHETIC.

In the early part of this work (see page 83), I stated that Dr. Gray, of Richmond, intended to continue his experiments with oxygen gas,* and I now (June 9th) give his conclusions, which he has kindly sent me. After employing it in six cases of teeth extraction, in none of which was there profound anæsthesia, only its first stage, he states:—"On both occasions the gentlemen present fully concurred with me that oxygen gas is undoubtedly anæsthetic for two or three minutes after withdrawal of the gas. It will be noted that the drawing of *the last* teeth in all the patients gave pain. That oxygen gas is not anæsthetic to the same degree as nitrous oxide, we equally agree."

ON THE USE OF ANÆSTHETICS, ESPECIALLY CHLOROFORM, IN DENTAL OPERATIONS.

I have before me the proceedings of two dental associ-

* Published by Richmond, Va., Medical Monthly, June, 1879.

ations, both containing as members, gentlemen of culture, having a medical as well as a dental education, while there were present to aid them medical men who had given the subject of anæsthetics careful study, who had much experience, and had performed numerous experiments with the various agents employed.

The president, in opening the discussion, at a meeting of the British Odontological Society, stated, that the subject for discussion was, "The use of Chloroform in Dental Operations," and that it had been suggested by the editor of the *British Medical Journal*, in commenting upon the death of a child two years and a half old, in May, 1878, from the effects of chloroform administered to facilitate a dental operation. He concluded his remarks on the case with the following query: Is it ever right to give chloroform for dental purposes? We wish the Odontological Society would pronounce an authoritative opinion on the subject, and were they to do so, absolutely forbid it."

After a full and free discussion, "the president said that all who had spoken had agreed that the use of chloroform in dental operations could not be absolutely forbidden, but that it should be restricted to very exceptional cases. Mr. Charles Tomes added some very practical suggestions; he said it should only be given at the patient's own house, and with the patient in a recumbent position. His own opinion was that a previous consultation with the medical attendant of the patient was also desirable. He proposed that the society should adopt these suggestions in the form of a resolution, thus:—'That it is the opinion of the society that the use of chloroform in dental practice should be restricted to very exceptional cases, that it should only be given at the patient's own house, and with the patient in a recumbent position, and that whenever circumstances will admit of it, a previous consultation with a qualified medical practitioner is highly desirable.' This resolution not having been passed, the president said he would be sorry to urge the society to come to a definite conclusion against their inclinations. No doubt practitioners in London and other large towns were more favorably situated as regarded the facility of obtaining advice and assistance than were their brethren in the country, and it was possible that an unfair

use might occasionally be made of the resolution by the legal profession. He would not, therefore, press it. It was the less necessary since all the speakers had agreed that though the use of chloroform might be occasionally justifiable, it was very undesirable to use it in any case where the services of other and safer anæsthetics could be made available, and he felt sure that the strong conviction of the danger and responsibility attached to the use of chloroform which had been expressed by some of the speakers would have great influence with the profession."

Thus we see that the British Odontological Society would not or could not pass an authoritative opinion on this all important question. We find the same disposition on the part of an American society* to continue using chloroform in dental operations, notwithstanding the dangers offered by this agent. Its chairman, Dr. J. J. Caldwell, of Baltimore (not a dentist), after preparing a careful report ending with a list of the various anæsthetics, gives the following opinion:—"Of these, preference has been given to sulphuric ether, chloroform, and nitrous oxide gas, both as regards safety and efficiency. It is well to know which is the safest, and, at the same time, the best for the purpose of the dentist. This knowledge can only be obtained by experiments, and *experiments thus far have proven adverse to the use of chloroform.*"

"Death at the hands of the dentist is, relatively speaking, much more common than at the hands of the surgeon, when chloroform is used. The explanation seems to be found in the fact that anæmia of the brain is induced by the drug, which assuredly depresses all the vital functions, and this anæmia inducing syncope, is again reflected on the heart, inducing paralysis of that organ; then, with the two legs of the great tripod of Bichat taken away, the catastrophe is precipitated. Hence decubitus must be insisted upon."

Dr. Thompson, a distinguished dental surgeon, who is chairman of the Committee on Anæsthetics of the society for the years 1879–80, stated the following:—"In past years when the subject of anæsthetics had been taken up, it seemed to have fallen through of itself. It is a subject that should

* Maryland and District of Columbia Dental Association, Washington, D. C., October 8th, 1878.

never be dropped without complete exhaustion. We are remiss in our duty if we allow it to go with anything short of exhaustion. The practice of anæsthesia is one that should command a great deal of study and caution. It has been stated here to-day that we can do a great deal of injury to our patients by not giving enough as well as by giving too much. That is true. Timidity dulls perception, but boldness in the exhibition of anæsthetics enables the operator to exercise more caution.

"He who gives nitrous oxide indiscriminately runs a risk of killing his patient at any time. In administering an anæsthetic we can have some indication of trouble, and this must be recognized. We also know that from idiosyncrasy often ensues failure. There are some diseases that must be attended to previous to bringing to a condition of anæsthesia.

"A patient came to me claiming to be perfectly healthy, but there was a lymphatic appearance that made me suspect that all things were not right. The physician said, 'Go on; it is all right.' We gave her gas, and the first few inspirations went on very nicely. Some more, and she showed indications of serious heart trouble. I stopped the gas and used the battery. She revived, but, after a little, went off again, showing that it was not the gas that was the sole cause.

"Now, relative to the restoration from anæsthetics, I have found nitrite of amyl of extreme importance. I had a case where the patient was given up as dead, when by the exhibition of nitrite of amyl full resuscitation occurred."

Dr. Hodgkin says:—"A resume of the attitude of the professions of medicine and dentistry on the subject of anæsthetics and their value and action may here be given, and as dentists you are naturally so strongly interested in the subject as to justify an expectation that this will be complete, and yet it is a difficult thing to do; for science, though so exact, is yet variant in the enunciation of her dogmas through her chosen apostles. The unanimity of division between the northern and southern sections of our land on the relative dangers of ether and chloroform is well known. The wave which seemingly threatened the destruction of the chloroformites was driven back by the accident of the late Civil War, which proves that the large percent-

age of deaths at the hands of those using chloroform in civil hospital cases, did not occur in the field and under average war circumstances. The advocates of ether still cling to that drug as *the* anæsthetic, claiming for it exemption from fatal effects in all but foregone cases."

The report of the chairman was followed by a report of the president, Dr. B. F. Coy, a well-known dental surgeon, of Baltimore, which we are unable to give in full for want of space, but which contains the following statement:—"Nitrous oxide gas, especially the condensed gas in cylinders, answers nearly all the purposes for the dental surgeon, but tedious operations on the bones of the face require an agent more durable in its effects; then use the best chloroform and no mixture with ether (p. 56)." Again, in conclusion, he states:—"An experience of over thirty years in the use of anæsthetics without accident or serious untoward symptoms, secures the right to speak warmly upon a subject that has given the human race the greatest blessing in surgery, of which they have been the recipients in ancient or modern times." In summing up the discussion in which the writer took part, Dr. Coy states:—"I did not expect to speak upon this subject, as it was well discussed. My experience with the condensed nitrous oxide gas has been very satisfactory. I have never had a patient show any ill effects from its use. I have given chloroform very often, and a great many times the posture necessary was a sitting one. I have sometimes found it necessary to throw my patient back into a horizontal position. . . . I have, of late, made use of nitrite of amyl as a restorative in the use of chloroform, and for establishing the action of the heart, when becoming too much depressed, with good effects."

Now, in carefully sifting this evidence, what do we find? *First.*—That chloroform is not absolutely necessary for any or all the ordinary operations in dental surgery; except, in a few tedious or rare instances, or where the actual cautery is employed. This powerful and dangerous agent, chloroform, should never be given unless a medical assistant be present, and the following means at easy command:—A bottle of nitrite of amyl, a portable galvanic or faradic battery, liquor ammon. fort., ice, a pair of catch-forceps, and an air-bag with nose-piece, to carefully inflate the lungs. It

should never be given in the dental chair, but always in the reclining position. Pure sulphuric ether has been since its discovery, and is now, employed by the dental profession of New York and Philadelphia in all operations in dental surgery, without accident and with perfect satisfaction. Mr. Charles Tomes, of London, reported that, in a visit to a New York hospital, he had seen several cases of cleft palate who were successfully operated upon under ether and kept under its influence without impeding in the least the movements of the operating surgeon. All danger from bleeding was obviated by laying the patient on his side, so that the blood could run into the cheek and out at the angle of the mouth. After this evidence of what was possible, he might be pardoned for thinking that the adaptation of ether to dental requirements was merely a question of management."

The following is the opinion of Dr. J. E. Garretson, expressed in a letter to the writer in 1878, on this important subject; and there is no one in this city who has more experience or better opportunities for testing the value of the agents of which we write, in a class of operations the most difficult to manage under anæsthetic impression.

"I cannot doubt that the circulation of the book will be large. Anæsthetics in surgical practice is a subject of the greatest consequence. Let me express my gratification at the special care with which you have presented the matter of chloroform. While using chloroform more or less every day out of sheer necessity, yet I am not less afraid of it than had Faust occasion to be of his convenient agent Mephistopheles. Certain it is I never allow myself to be caught alone with it. What prayer was to the savant's devil, ether is to chloroform. I play the one against the other."

"Concerning the healing of wounds under the employment of chloroform and ether, I am emphatic in my convictions of an evil residing in the former; to the fact of such evil I had my attention first directed during the war. Flaps glaze but poorly under the chloroform impression, when compared with that of ether. Force at large seems to be debilitated. I desire to be put on record as condemning the use of chloroform wherever the surgeon can get along without it."

An equally able surgeon, well known for his extensive knowledge of every department of surgery, gave the following testimony in the discussion before referred to, in the Odontological Society of Great Britain.*

"Mr. Jonathan Hutchinson said he could, from personal experience, testify to the superiority of nitrous oxide gas over other anæsthetics. He would allow any one who had had some experience in the use of the gas to give it to him, but he would only take ether from a thoroughly qualified person, and would not allow any man living to give him chloroform. He had used both ether and chloroform largely; he had lost one patient from chloroform eighteen years ago, and had had many alarming cases; he had seen fatal cases also under the care of others. During the last six years he had almost invariably used ether, and during that time he had not had a single alarming case. He strongly disapproved of some of the complicated inhalers now in use, in which, for the sake of economising ether, the patient was made to ré-inhale his own breath, thus taking in a quantity of carbonic acid as well as ether. In the only bad cases connected with ether which he had seen, some such apparatus had been used. He greatly preferred a simple leather mouth-piece, perforated at the top, with a sponge and towel inside; in this way the patient got plenty of air and plenty of ether. There certainly were a few cases in which chloroform was preferable, viz., for old people and very young children. Old people over sixty did not always recover readily from ether narcosis. He had met with several cases in which there had been alarming continuance of insensibility, and in one case death seemed to be partly due to this cause. Chloroform seemed to be less dangerous than ether to old people; and in the case of infants there seemed to be practically no danger at all, while it was most dangerous to young people. At the hospital in Moorfields there used to be, on an average, a death from chloroform every year, and they were nearly always young people operated upon for strabismus. Chloroform was certainly more convenient in some respects and pleasanter to take than ether.

* British Journal of Dental Science, and American Journal of Dental Science, Baltimore, April, 1879.

Patients who had tried both almost invariably preferred the former; but he thought it criminal to place a patient in danger of losing his life by giving chloroform, when ether had been found to be so much safer."

"The president asked Mr. Hutchinson whether he did not think that dental operations presented some peculiar features which entitled them to special consideration."

"Mr. Hutchinson said he could not call to mind any points in which dental operations differed materially from those in general surgery; he thought that the opinions he had expressed would apply equally well to them."

TREATMENT OF POISONING BY CHLOROFORM, OR CHLOROFORM NARCOSIS.

Prof. Gross's Method.—The surface of the chest should be smartly slapped with the fringe of a towel dipped in ice water; a piece of ice introduced into the rectum; the head must be lowered and the legs elevated, and ammonia held to the nose, an assistant meanwhile practicing artificial respiration. (See also page 104. The means to be resorted to to prevent death from chloroform.)

Mr. Clover* finds, in spite of all his care, that chloroform will cause the action of the heart to fail, and he is not so wedded to it that he will allow his patient to be killed by it. But he states, "remove the chloroform and administer ether vapor for a few inspirations," (or what is still better, as recommended by the late Dr. Sansom,† continue with the ether until the operation is finished.)

Dr. Clover also remarks, "The mixture of nitrite of amyl with chloroform has been strongly advocated recently

* A Guide to Therapeutics and Materia Medica. By Robert Farquharson, M. D. Second American edition. Enlarged and adapted to the U. S. P. by Frank Woodbury, M. D., physician to the German Hospital, Philadelphia. Philadelphia: H. C. Lea, 1879, p. 208.

† Antagonism of Chloroform and Ether.—Dr. Greenhalgh stated at the meeting of the Obstetrical Society of London (February 7th, 1866), that he had requested the late Dr. Sansom to administer chloroform to a lady during the removal of a large polypus from the uterus. Shortly after the administration of the chloroform, and before complete anæsthesia was induced, her pulse began to falter, her breathing became embarrassed, and her countenance livid. Dr. Sansom, without delaying the inhalation, substituted ether with the best results. Dr. Greenhalgh begged to ask that gentleman if he had

by Dr. Sandford, an American physician. I have tried it in a dozen cases, and find that it produces insensibility rapidly; and if the anæsthetic is then removed, the recovery is very satisfaetory, but when the inhalation is continued for three or four minutes, there seems to be nearly as much subsequent depression."

CHLOROFORM AND CHLORAL IN POISONING BY STRYCHNIA.

A large and poisonous dose of strychnia produces symptoms very closely resembling those of tetanus, but are more strongly marked and rapidly reach their maximum. The symptoms usually come on in twenty minutes to half an hour, and are not usually delayed beyond an hour. The first symptoms are general uneasiness, with restlessness and soreness of the limbs; shooting pains, like electric shocks, occur in various parts of the body, often first in the back and down the arms and legs. Tetanic and paroxysmal contraction of the muscles soon set in—in my experiments with frogs, cats, rats, and dogs, it acts at once—and these symptoms grow rapidly worse, and make the body rigid while the paroxysm lasts.

If the dose has been large the paroxysm is usually very severe. In one case, in which a woman had taken half a grain by mistake, there was thirty-seven or more paroxysmal contractions of the muscles, and the respiratory movements at times were almost completely arrested, so that her face became bloated and livid, the jugular veins standing out in the neck, and the eyes staring and prominent. Each of these spasmodic attacks lasted from a few seconds to a minute, and then ceased. The mind of the patient was un-

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adopted a similar practice in other cases with good effects; and, if so, whether he considered that the vapor of ether could be regarded as an antidote to the evil consequences of chloroform, and whether he could offer any physiological explanation of how such beneficial effeets are brought about. Dr. Sansom replied that it was his constant practice to administer ether if in any case where chloroform seemed to produce a depressing effect; indeed, usually in prolonged operations he thus maintained the anæsthesia. The substitution, or rather addition, was never attended by any return of sensation. He always found the plan answer admirably; it certainly restored the force of the circulation.—(Medical Times and Gazette, February, London, 1866.)

affected, and the suffering was intense. Any movement, sometimes the slightest, would excite a paroxysm. My patient recovered under the use of chloroform and animal charcoal, and careful watching and sustaining of her strength. Usually a fatal termination is due either to exhaustion from the repeated convulsions, or to asphyxia from spasm of the muscles of the chest, which is obviated by insufflation. Strychnia tetanizes, neither through the brain muscles nor nerves, but through the spinal chord.

Treatment.—The antidote to poisoning by chloral is strychnia (see page 223); and, *vice versa*, chloral has been found antagonistic to strychnia. Chloral modifies the strychnia symptoms to a great extent, and the first agent, therefore, to administer in poisoning by strychnia, is chloral, and then chloroform by inhalation to relieve tetanic rigidity. The chloral is given in doses of at least twenty grains by the mouth; or sixty grains in starch water by injections, by the rectum. The fatal closure of the jaws takes place in a few minutes, if the dose be a large one; if smaller, in five or six hours. The minimum quantity of strychnia required to destroy life in man is about one half a grain. If the patient be able to swallow, administer copious draughts of warm water with tannic acid in solution, or strong oak-bark tea, as this renders the strychnia inert. The stomach pump is useful, but it can rarely be used, owing to the effort to pass the tube into the stomach causing violent spasm.

Prof. Husemann, of Göttingen, has been engaged in a long series of observations on the antagonistic and antidotal action of drugs. Some of his investigations, which relate especially to chloral, are translated for the *London Lancet*, vol. i, 1879, p. 382, from the *Archiv. für Exper. Pathologie*; and although we find but little that is new, yet some of the confirmatory facts are worthy of publication. He says, "Chloral hydrate is known to act as an antidote to strychnine, lessening the spasm, and even preventing death. It has a similar action in the case of the mixture of strychnine bases sold under the name of brucia, and also against the opium alkaloid thebaia, which simultaneously tetanizes and lessens sensibility. The spasms produced by chloride of ammonium diminish under the employment of non-fatal doses of chloral hydrate, and can, indeed, be completely stopped."

(For the specific effects of hydrate of chloral, see conclusions on page 207.)

ON THE CHOICE OF ANÆSTHETICS.

For all minor operations in surgery, at the house of the patient or in private office (when the cost of the anæsthetic is of no consequence, and where disagreeable odor is to be avoided), nothing has yielded us such satisfactory results as *hydrobromic ether.* For all dental operations (except tedious and protracted dissections on the mouth), the safest anæsthetic is *nitrous oxide gas*, which, in its results, is exhilarating and most satisfactory, and with but little effort produces complete insensibility to pain, and is most rapidly eliminated from the system. For dangerous and protracted operations, the agent which has been employed in this city and in the United States is the pure *ether;* the proofs of its safety are full and complete. Chloroform, as an anæsthetic, has a long and painful record of valuable lives lost from the time of its introduction to the present day, so that no one is justified in using it unless the ordinary agents specified above fail him, or unless he has to employ the actual cautery; even with little children it is not absolutely safe,* and a reference to the body of this work will show that numerous deaths follow its use.

Every combination of chloroform, its various modes of administration in both large and small quantities and mixed with other agents, have been experimented with, but those who have employed it most have, when its positive fatal action is seen, had at last to resort to ether.

EFFECTS OF SUDDEN REDUCTION OF TEMPERATURE AFTER ANÆSTHESIA.

In a careful study of the secondary causes of death from *ethers* and *chloroform* and their compounds, one important symptom has impressed the writer, that is, the almost uniform reduction of temperature preceding death. This occurs after important and protracted operations, and often is hastened by careless removal from the warm, nay hot, impure atmosphere of the operating-room to the adjoining ward,

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* See page 109, deaths from chloroform in children; also, table of deaths from this agent, page 113.

exposing the damp, warm skin to the contact of a sudden cool atmosphere. Again, the attendant should be a medical man of experience, who should watch the case until reaction is fully established, and see that the nurse keeps the patient warm for at least six or seven hours, and administers both stimulants and nourishment. If these means are neglected and the skin of the patient is chilled, gradually he sinks into an unconscious state, from fluids which collect in the bronchi, lungs, and kidneys, and dies; mucous secretion and serous effusions suffocating the patient. If bronchitis remains after reaction, treat it by means of small and repeated doses of spirits of ammonia in mucilage of gum arabic, with senega; also, counter-irritation by means of lotion of oil of turpentine and soap liniment.

Now we come to the conclusions concerning this matter. "What is the number of recorded cases of deaths from chloroform?" says Farquharson, the latest English authority. "Fatal accidents from chloroform have become so alarmingly frequent of late—the total number, according to Bartholow, amounting to five hundred—that some surgeons even consider its use unjustifiable." We have no doubt there have been more than five hundred. We desire, however, to be within bounds, and only print those cases that have been fully authenticated. The number of deaths from chloroform contained in our table on page 113, when added to those already given in this paper, make the ghastly sum total of *three hundred and seventy*. Just as the last of these pages were passing through the press, comes the sad news of another painful death by chloroform, a true case of paralysis of the heart, making three hundred and seventy-one. The following is the published report of the case:—

"Mr. John K. Cornwall,* about forty-five years old, and apparently in fair general health, was suffering from an ailment that required the repetition, after the lapse of two years, of a painful surgical operation. He told Dr. Chambers that he could not bear the pain without taking an anæsthetic. He greatly preferred chloroform to ether, because the latter, he said, made him sick. Dr. Chambers told him that if he insisted on taking chloroform he must

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* New York Times, May 16th, 1879.

call in another physician of experience. This led to the attendance of Prof. Louis A. Stimson.

"Mr. Cornwall purchased the chloroform himself. At two and a half o'clock, on Thursday afternoon, May 15th, 1879, all was in readiness. Under the advice of both of the physicians, the patient was induced to make an attempt to undergo the operation without the chloroform, but at the very beginning his courage failed. He was then told to lie on a bed, because a reclining position of the body is usually viewed as safer than an upright one for the administration of chloroform. Dr. Chambers poured not more than half a spoonful of the liquid on a towel, and laid the moistened part over Mr. Cornwall's mouth and nostrils, at the same time telling him to breathe naturally, as though the towel was not there. Prof. Stimson, assuming the part requiring the greater amount of experience, held his fingers on the patient's pulse, which was beating regularly. There were barely three inhalations of the chloroform when Prof. Stimson discovered that the pulse had suddenly stopped. The towel was at once removed, but after a brief fluttering of his breath it stopped. Artificial respiration was tried, but without success. Previously a few drops of nitrite of amyl were put on a piece of cloth and placed at his nostrils, but either because there was not enough breath to carry its vapor into the lungs, or from some other cause, it failed to have any effect. Nitrite of amyl usually causes an immediate quickening of the heart's movement, and is therefore recommended as an antidote to the dangerous effects of chloroform.

"The two physicians at last gave up hope of their patient's recovery, and sent for his wife, who had been persuaded to go on a visit to a friend to remain during the operation. Dr. Edward G. Janeway, one of the commissioners of the Health Department, was called to assist Drs. Stimson and Chambers in making a *post mortem* examination. All the organs of the body were examined, but in none was there found, on the first examination, any mark of disease or irregularity that could have caused death. Then Dr. Janeway sent for a microscope in order to make a closer examination. No fatty degeneration had been observable with the naked eye, but with the instrument the substitu-

tion of fat in place of muscular fibre could be seen plainly. This substitution of fat serves to weaken the muscular action of the heart and to make it irregular.

"Coroner Croker was summoned by Dr. Chambers, and Deputy Coroner McWhinnie viewed the body. A permit of burial was granted by the coroner listening to the statements of the three physicians. The cause of death reported to the Bureau of Vital Statistics was 'fatty degeneration of the heart.' It is explained by Dr. Chambers that, though the fatty degeneration had not yet made progress enough to cause death under ordinary circumstances, yet it had been able to do so under the first accelerating effects of the chloroform. Commissioner Janeway told Dr. Chambers that no physician could possibly have discovered the condition of Mr. Cornwall's heart from observations made before death. Mrs. Cornwall, and a brother and a brother-in-law of the dead man, say they believe the physicians did the best they could have done under the circumstances. The burial permit was granted, 'pending an inquest;' but it is said there will be no inquest because Coroner Croker judges that the allegations of three reputable physicians, Commissioner Janeway, Prof. Stimson, and Dr. Chambers, as to the cause of death, make the holding of a formal inquiry unnecessary."

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DUGAS, LOUIS A., Augusta, Ga.—"Local Anæsthesia," *Southern Medical and Surgical Journal*, vol. for 1855–6.

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SNOW.—"On Chloroform," a new edition, and a memoir by B. W. Richardson, London, 1858.

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See a full account of the discovery of modern anæsthesia by Prof. H. G. Bigelow in "A Century of American Medicine" (H. C. Lea, published 1876). Also, "Discovery of Anæsthesia," by Dr. J. M. Sims, *Virginia Medical Monthly*, May, 1877; and the "History of Modern Anæsthetics," by Sir James Simpson, of Edinburgh. This distinguished physician discovered the anæsthetic properties of chloroform, and employed it first in year 1847. (James Campbell & Co., Boston, Mass.)

KENTUCKY THE FIRST STATE OF THE UNION IN WHICH ANÆSTHESIA WAS EMPLOYED IN THE OPERATION OF OVARIOTOMY.

"In October, 1846, sulphuric ether, or letheon, as then called, was first employed as a pain-destroyer in a surgical operation by Dr. Warren, of Boston. Only one operation of ovariotomy in this country was performed during this year, which was by Dr. John L. Atlee, before the date above given. In 1847 Dr. Robert Thompson performed the only operation for that year; but no mention is made of the fact that letheon was employed. Both operations unsuccessful. In November, 1847, Prof. Simpson, of Edinburgh, employed for the first time chloroform as an anæsthetic. On March 15th, 1848, Dr. Clay, of Manchester, England, performed his first ovariotomy under the influence of chloroform—successful. On March 21st, six days afterwards, Mr. H. G. Potter, of Newcastle, performed a similar operation under the influence of chloroform—unsuccessful. On April 6th, sixteen days later, Dr. Henry Miller, of Louisville, Ky., performed in that city ovariotomy under the influence of chloroform, upon a woman from the State of Indiana—successful; second case in the world under anæsthesia.

During this year there were three other ovariotomies performed in this country, though they were after Dr. Miller's; only one of the three was successful."*

NOTES ON THE USE OF NITROUS OXIDE AS AN ANÆSTHETIC IN STRABISMUS OPERATIONS.

BY DR. ARTHUR MATHEWSON, BROOKLYN, N.Y.

In these five cases the patient was seated in a dentist's operating chair, tipped back as far as possible, and the gas drawn from the apparatus of Johnston Bros. (1260 Broadway, New York), for the use of the liquid nitrous oxide. This has an inhaler fitted with a valve, so that atmospheric air can easily be admitted, and a cup-shaped cover to go over mouth and nose. The patient in each case went quietly under the influence of the anæsthetic without any of the suffocating sensations caused by ether. Vomiting occurred in two of the cases. There was no unpleasant after-effects. There was in some of the cases a blue and livid color of the face, which passed off on admission of air. Blood very dark, with scarcely any bleeding while the lividity continued. Full muscular relaxation did not accompany the anæsthesia in all the cases, but this was not an inconvenience, as it might prove in cataract and other operations. The minimum and maximum quantities of gas consumed in these cases were seven and twenty gallons, at a maximum cost of one dollar.†

THE METRIC OR DECIMAL SYSTEM.

The Metric System has been legalized in the United States and Great Britain, employed by other civilized nations, and is rapidly becoming an essential part of the international language of science. It has been adopted for the profession of this country in the recent meeting of the American Medical Association (June, 1879). Although our work is not printed in this system, we have given the subjoined tables and scales with rules, so that any one can reduce the apothecaries weights; also the thermometric scales.‡

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* Dr. Nathan Bozeman, Medical Record, New York, June 7th, 1879.

† Abstract from Transactions of the American Ophthalmological Society, New York, 1878.

‡ Chicago Medical Journal and Examiner, September, 1879.

THE METRIC SYSTEM IN MEDICINE.

Old Style.		Metric.
♏j or gr. j equals		06 Gm.
fʒj or ʒj "	4	"
f℥j or ℥j "	32	"

The decimal *line*, instead of *points* makes errors impossible.

As .06 (Drug) is less than a grain, while 4 and 32 (Vehicle) are more than the drachm and ounce, there is no danger of giving too large doses of strong drugs.

C. C. (cubic centimetres) used for Gms. (grammes) causes an error of 5 per cent. (excess.) A teaspoonful is usually 5 Gms.; a tablespoonful, 20 Gms.

Two examples will illustrate the mode of writing prescriptions.

℞. Extr. Coloc. Comp. ʒiss.
Extr. Colch. Acet. gr. xii.
Extr. Digitalis, gr. vi.—M.

Make into twenty-four pills.
Sig. One pill every three hours.*

would in metric terms be written :—

	Gm.
℞. Extr. Coloc. Comp.	6 |
Extr. Colch. Acet.	| 75
Extr. Digitalis,	| 36.

Make into twenty-four pills.

or the following prescription :—

℞. Potassii Bromidi, ℥j.
Elix. Aurantii, ft. ℥viii.—M.

Sig. A tablespoonful once or twice a day.†

would in metric terms be written :—

℞. Potassii Bromidi,	32	Gm.
Elix. Aurantii,	256.	C. C.

M.

* A valuable gout pill.

† In cases of disturbance of the brain or in chronic alcoholism.

Thermometry.

Centigrade Scale.	Fahrenheit Scale.
45°	113°
	112°
44°	111°
	110°
43°	109°
42°	108°
	107°
41°	106°
	105°
40°	104°
	103°
39°	102°
	101°
38°	100°
37°	99°
	98°
36°	97°
	96°
35°	95°
	94°
34°	93°
	92°
33°	91°
32°	90°
	89°
31°	88°
	87°
30°	86°

METRIC MEASURES OF LENGTH.

Millimeter, . .	0.001	of a Meter, . . .	0.03937 in.
Centimeter, . .	0.01	" " . . .	0.39370 "
Decimeter, . .	0.1	" " . . .	3.93707 "
Meter, ...	**1.**	**Meter, ...**	**39.37079 "**
Decameter, . .	10.	Meters, ...	393.70790 "
Hectometer, . .	100.	"	3937.07900 "
Kilometer, . . .	1000.	"	39370.79000 "

METRICAL WEIGHTS.

Milligramme, . .	0.001	of a Gram, . . .	0.015 gr.
Centigramme, .	0.01	" " . . .	0.154 "
Decigramme, . .	0.1	" " . . .	1.543 "
Gram, ...	**1.**	**Gram, ...**	**15.432 "**
Decagramme, . .	10.	Grams, ...	154.323 "
Hectogramme, .	100.	"	1543.234 "
Kilogramme, . .	1000.	"	15432.348 "

The exact equivalents of the grain, drachm, and ounce (troy) in grams; of the gram in grains; of the minim, fluidrachm, and fluidounce in cubic centimeters; and of the cubic centimeter in minims, are as follows:—

1 grain, troy, is equal to 0.065 — gram.
1 drachm, troy, is equal to 3.888 — grams.
1 ounce, troy, is equal to 31.103 + grams.
1 gram is equal to 15.43234874 grains troy.—*Prof. Miller.*
(1 avoirdupois pound is equal to 453.592 + grams.)
(1 avoirdupois ounce is equal to 28.350 + grams.)
1 minim is equal to 0.062 — cubic centimeter.
1 fluidrachm is equal to 3.697 — cubic centimeters.
1 fluidounce is equal to 29.573 — cubic centimeters.
1 cubic centimeter is equal to 16.231 + minims.
(1 meter is equal to 39.370432 inches).—*Capt. Clarke.*

APPENDIX.

HYDROBROMIC ETHER OR BROMIDE OF ETHYL AS AN ANÆSTHETIC.

The hydrobromic ether or bromide of ethyl was discovered by Serullas in 1827, but received no special attention until Dr. Thomas Nunneley, of Leeds, made some experiments with it on animals in 1849. Dr. Nunneley brought the subject again before the profession, by a paper read at the meeting of the British Medical Association in 1865, in which, in conjunction with another anæsthetic, he says he had employed the one or the other in all the principal operations at the Leeds General Eye and Ear Infirmary. This was at the time when chloroform held such complete sway in England, that no importance was attached to Nunneley's experience or experiments, and he had no one to follow him in using it, and we hear no more of it until 1876, when some experiments were made with it in France, by Rabuteau, on the lower animals, but evidently without a knowledge of the fact that this had been done previously in England by Nunneley.

I then took up the agent without the knowledge of the experiments of Dr. Nunneley, of England, and had it made in Philadelphia by Professor Remington, and with two friends began experimenting in September, 1877, using it first on myself, and then upon my patients. After satisfying myself as to its efficiency and safety as an anæsthetic, I laid the subject before the Pennsylvania State Medical Society in 1878, and a record of ten cases, with my conclusions, which were published in the volume of their Transactions for that year. In August, 1879, I brought it before the British Medical Association at Cork, and in September of that year, I presented a report of one hundred cases before the International Medical Congress

at Amsterdam (to which I was a delegate from the American Medical Association), up to March, 1879, when the second edition of my work on anæsthetics went to press. I had published a report of twenty-five successful cases in quite a variety of surgical operations, and had not only employed it at my daily ear clinic, but also in the Jefferson Medical College Hospital, and administered it in April, 1879, to a patient of Dr. Samuel W. Gross, at the public clinic, when he (Dr. Gross) removed a hyoid cyst in front of the neck of a child. Dr. R. J. Levis, who was at this clinic, for the first time saw it employed, and became much interested in its use.

I thus compelled chemists to make it, by producing a demand for it, and gave them, through Dr. Green, a good formula free from phosphorus; I interested surgeons all over the country to try it, and especially the surgeons of this city, by bringing it in every way before their attention. Subsequently the whole number of cases in which it has been employed by myself and friends up to the present time, June, 1880, will number some eight or nine hundred.

I cannot but feel disappointed that two deaths, not produced by it, should have been associated with it,* as such accidents will be employed by those having a prejudice against the ether, to condemn it on theoretical grounds. It is my firm conviction that, although in several instances recently, the use of this anæsthetic has been attended with persistent vomiting, in the hundreds of cases in which it has been employed, chiefly in Philadelphia, in not one single instance has it caused cerebral trouble, or any of the symptoms produced by the action of free bromine,† which are as follows: When dogs are confined in an atmosphere of bromine vapor, they suffer a profuse secretion from the eyes, nostrils, and fauces, with cough, hoarseness, dyspnœa. I have experimented upon frogs, cats, dogs, rabbits, and various other animals, by subjecting them to an atmosphere highly charged with the

* The bromide of ether as an anæsthetic, by Marion Sims, M.D., LL.D. *New York Medical Record*, April 3, 1880.

† In both the instances of injurious effects stated to have been produced the ether was not absolutely pure, as determined by Professor Barker (for me) of the University of Pennsylvania.

vapor of hydrobromic ether, and in no instance was there the slightest irritative effects as described above.

Deputy Coroner Beam, of Philadelphia, made an investigation of the circumstances of the death of William Linderman, eighteen years old, of Schuylkill county, while upon the operating table at the Jefferson College Hospital, June, 1880, under the influence of the new anæsthetic, bromide of ethyl, and about to be treated for stone in the bladder. He had been about sixteen weeks under the care of Dr. R. J. Levis, one of the strongest advocates of the new anæsthetic, and was taken to the hospital by his direction. Linderman's health was very poor at the time, Dr. Ames applied the bromide. The whole quantity of bromide of ethyl employed was four fluid drachms. Just after the cutaneous incision had been made by Dr. Levis there was noticed imperfect respiration. The towel was removed from the face at once and the cheeks slapped to induce inspiration. The lips at the time were pinkish and no marked cyanosis was noticed. (He had evidently fainted from shock). Every means was employed but inversion of the body but without avail. The patient was in such a condition that something had to be done, because he could not tide over the hot weather; 96°-98° in the shade.

Dr. J. G. Lee, the Coroner's Physician, testified that he found the brain congested, *the lungs far advanced in consumption, and the kidneys and liver enlarged*, and two large encysted stones in the bladder. His opinion was that *Linderman could not have lived over a week or two at any rate.* Dr. Lee said further, that he had experimented with the bromide on animals without bad results. In his opinion death resulted from exhaustion and prostration, the result of phthisis. The jury took the same view in their verdict.

In subjecting the new anæsthetic to this most severe test we do not think our friend, Dr. Levis, was doing justice to it; knowing the extreme debility of the patient, and that the most simple nervous *shock* would render him liable to death. Hundreds of patients have thus died. Again, when ordinary ether, chloroform, or other anæsthetics cause fainting, which was no doubt the result in this case, artificial respiration has to be resorted to; now

we were reliably informed that when this useful means was resorted to by alternating and relaxing the chest walls, *the pus which was in this man's lungs was forced into his bronchial tubes.*

In some recent experiments on animals I crowded four ounces (the quantity stated to have been used by Dr. Sims) upon a dog for several minutes, by means of a tin inhaler, until he became apparently dead, with no perceptible action of the heart or lungs, but his expression of eye was clear, and the pupil was dilated, while there was no secretion from the eyes or nostrils. The apparatus was removed in the space of four minutes, and he was exposed to the air, when at once he began to breathe, and by the end of the six minutes, he had almost entirely recovered consciousness.

The dog did not seem much inclined to move for ten or twelve minutes afterwards. While this dog was only partly under the influence of this anæsthetic, having at first caught the inhaling apparatus with his under-teeth; there was a good deal of rigidity, and slight tetanic movements of the extremities, resembling the effects of nitrous oxide gas; but this was overcome by the free use of the ether. Now, had we been using chloroform, just before we would have been ready to perform any experiments upon the animal, he would have been dead, and no removal of the anæsthetic nor the introduction of atmospheric air would have been of any avail. Again, if Squibb's rectified and absolute ether had been employed; we must have super-saturated the animal, and been annoyed by the expectoration of large quantities of mucus. Then we frequently have seen tetanic convulsions, requiring several assistants to hold the patient, with great reduction of temperature, from the use of ordinary ether. The rapidity of the anæsthetic action of hydrobromic ether and its rapid elimination from the system by the lungs, are two of its chief merits for all operations that are not prolonged. If an operation is to be very tedious, and requires from one to two hours, we would advise the additional use of purified *sulphuric ether to the anæsthetic. We would therefore recommend pure hydrobromic ether in operations not lasting over forty minutes.* There is one great advantage in the use of this agent, that the administrator must attend to

the anæsthetic all the time, he cannot watch the operation and forget the patient for a few seconds, his whole attention must be given to keep up its action. We have often felt sure that the wet napkin, from the water, in the ordinary ether pressed over the patient's mouth by the weight of the body of the persons giving the ether, and watching the operation, were the indirect causes of the death of the patient. Within the last few days we have employed it in labour for the second time, and it has peculiar advantages in that it is so rapid in its effects, and the patient is comforted between the pains, but never passes into such a state of profound anæsthesia, that she is aroused by the expulsive effort, and has all her consciousness about her, and none of the depressing effects of ether or chloroform. It is also most valuable in these cases in changing the position of the child, also in bringing forward the neck of the uterus into its proper position. In neither of these instances was there disturbance of the bowels, or pain in the back or head. To the country practitioner who has to extract teeth, or perform all the minor operations in surgery it is a great boon, as it acts like nitrous oxide gas; it is well where a number of teeth are to be extracted, that a prop of hard wood attached to a string should be used, so as to prevent such an accident as once occurred in Philadelphia, under the use of nitrous oxide gas, as of the swallowing of a prop of cork. In many cases where you do not want a very profound narcotism with hydrobromic ether, the muscles of the patient become rigidly contracted. This condition occurred on a recent occasion, when we administered (℥i) of this anæsthetic and the operator's finger was caught and pinched, as also his forceps, and yet before operating we could touch the cornea with impunity. Although the impression passed away very rapidly, we extracted twelve teeth with entire success, the patient promptly recovering consciousness, and not feeling the pain. In the following case the patient went under it very kindly. This patient was a man of very nervous temperament. With three drachms of the hydrobromic ether, anæsthesia was produced without any struggling, and in four minutes from the time he had commenced to inhale it, the dentist had extracted ten teeth, and he had fully recovered consciousness, although ho had

just eaten a heavy breakfast of solid food. There was no nausea in either of these cases.

In a recent case of cataract extraction, the patient went beautifully under the influence of the anæsthetic, extraction was accomplished, and the patient recovered so as to be able to count fingers; yet owing to some strong coffee which she drank, from dyspeptic symptoms, or the swallowing of water soon after the operation, she became very sick at her stomach, and vomited for nearly twenty-four hours, and yet the case did well. In a case of operation for torticollis in a woman, she swallowed so much air with the ether, that as a consequence she complained of pain, of a hysterical character, in lower part of the abdomen, the same which is often the result of nitrous oxide gas inhaled, and too much air admitted.

A few days ago, we received a letter from Dr. J. Patterson Cassells, of Glasgow, a distinguished Aurist, and Surgeon to the celebrated Glasgow Infirmary; he writes, that he has used a specimen of the hydrobromic ether which I gave him at Cork, as vapor, in diseases of the middle ear, and has also employed it as an anæsthetic with success.

INDEX.

ERRATA.

On page 93, on fourth line from the bottom, for "pulse" read "pupil."
On page 145, for "Anæsthesia" read "Anæsthesie;" for "Medicine" read "Médecine;" for "Imperiale" read "Impériale;" for "Médicine" read "Médecine;" for "Pharmacié" read "Pharmacie;" for "Militaries" read "Militaires."
On page 147, eleventh line from the top, for Dr. "Samson" read "Sansom."
On page 155, on twenty-seventh line, for "syncopy" read "syncope."
On page 177, for "Hebdomadāire" read "Hebdomidare."